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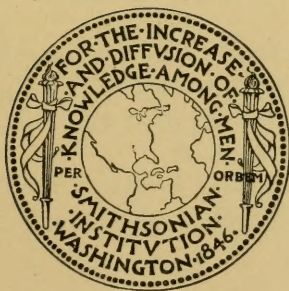
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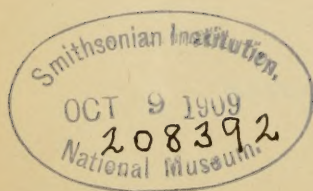
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## ADVERTISEMENT.

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The scientific publications of the National Museum consist of two series—Proceedings and Bulletins.

The Proceedings, the first volume of which was issued in 1878, are intended primarily as a medium for the publication of original papers based on the collections of the National Museum, setting forth newly acquired facts in biology, anthropology, and geology derived therefrom, or containing descriptions of new forms and revisions of limited groups. A volume is issued annually or oftener for distribution to libraries and scientific establishments, and, in view of the importance of the more prompt dissemination of new facts, a limited edition of each paper is printed in pamphlet form in advance. The dates at which these separate papers are published are recorded in the table of contents of the volume.

The present volume is the thirty-sixth of this series.

The Bulletin, publication of which was begun in 1875, is a series of more elaborate papers, issued separately, and, like the Proceedings, based chiefly on the collections of the National Museum.

A quarto form of the Bulletin, known as the "Special Bulletin," has been adopted in a few instances in which a larger page was deemed indispensable.

Since 1902 the volumes of the series known as "Contributions from the National Herbarium," and containing papers relating to the botanical collections of the Museum, have been published as Bulletins.

RICHARD RATHBUN,  
*Assistant Secretary, Smithsonian Institution,  
In charge of the United States National Museum.*

JUNE 20, 1909.





## TABLE OF CONTENTS.

	Page.
ANNANDALE, NELSON. Fresh-water Sponges in the Collection of the United States National Museum. Part I. Specimens from the Philippines and Australia.—No. 1690. June 19, 1909 <sup>a</sup> .....	627-632
New species: <i>Spongilla philippinensis</i> , <i>S. clementis</i> .	
BEAN, BARTON A., and ALFRED C. WEED. Description of a New Skate ( <i>Dactylobatus armatus</i> ) from deep Water off the Southern Atlantic Coast of the United States.—No. 1682. May 27, 1909 <sup>a</sup> .....	459-461
New genus: <i>Dactylobatus</i> .	
New species: <i>Dactylobatus armatus</i> .	
———. Descriptions of Two New Species of Electric Rays of the Family Narcobatidæ, from deep Water off the Southern Atlantic Coast of the United States.—No. 1694. June 21, 1909 <sup>a</sup> .....	677-680
New species: <i>Benthobatis marcida</i> , <i>B. cervina</i> .	
CASANOWICZ, IMMANUEL M. The Collection of Rosaries in the United States National Museum.—No. 1667. April 17, 1909 <sup>a</sup> .....	333-360
CLARK, AUSTIN HOBART. Comatilia, a Remarkable New Genus of Unstalked Crinoids.—No. 1668. April 27, 1909 <sup>a</sup> .....	361-367
New genus: <i>Comatilia</i> .	
New species: <i>Comatilia iridometriformis</i> .	
———. Descriptions of Seventeen New Species of Recent Crinoids.—No. 1691. June 19, 1909 <sup>a</sup> .....	633-651
New species: <i>Eudiocrinus ornatus</i> , <i>Amphimetra mortenseni</i> , <i>Heterometra compta</i> , <i>H. singularis</i> , <i>Stephanometra coronata</i> , <i>Colobometra discolor</i> , <i>Cyllometra taprobanes</i> , <i>Crotalometra annandalei</i> , <i>Crinometra pulchra</i> , <i>C. margaritacea</i> , <i>C. concinna</i> , <i>C. insculpta</i> , <i>C. gemmata</i> , <i>Psathyrometra mira</i> , <i>Mastigometra micropoda</i> , <i>Hypalocrinus springeri</i> , <i>H. ornatus</i> .	
———. Four New Species of the Crinoid Genus Rhizocrinus.—No. 1693. June 19, 1909 <sup>a</sup> .....	673-676
New species: <i>Rhizocrinus conifer</i> , <i>R. brevis</i> , <i>R. sabæ</i> , <i>R. robustus</i> .	

	Page.
CLARK, AUSTIN HOBART. On a Collection of Recent Crinoids from the Philippine Islands.—No. 1673. May 13, 1909 <sup>a</sup> . . . . .	391-410
New genus: <i>Crotalometra</i> .	
New species: <i>Phanogenia minima</i> , <i>P. delicata</i> , <i>Comanthus polycnemis</i> , <i>Pontiometra insperatus</i> , <i>Cenometra delicata</i> , <i>Ptilometra pulcherrima</i> , <i>Stenometra arachnoides</i> , <i>Crotalometra eupedata</i> , <i>Pachylometra levigata</i> , <i>Iridometra exquisita</i> .	
———. Revision of the Crinoid Family Comasteridæ, with Descriptions of New Genera and Species.—No. 1685. June 7, 1909 <sup>a</sup> . . . . .	493-507
New genera: <i>Cominia</i> , <i>Comactinia</i> , <i>Leptonemaster</i> , <i>Comissia</i> , <i>Nemaster</i> .	
New species: <i>Leptonemaster venustus</i> , <i>Comissia lutkeni</i> , <i>Nemaster grandis</i> .	
COCKERELL, T. D. A. Descriptions of some Bees in the U. S. National Museum.—No. 1674. May 13, 1909 <sup>a</sup> . . . . .	411-420
New species: <i>Emphoropsis vierecki</i> , <i>Mesotrichia abbotti</i> .	
New subspecies: <i>Emphoropsis murihirta murina</i> .	
———. See under Robbins, W. W. . . . .	381-384
COUTIÈRE, HENRI. The American Species of Snapping Shrimps of the Genus <i>Synalpheus</i> .—No. 1659. January 30, 1909 <sup>a</sup> . . . . .	1-93
New name: <i>Synalpheus lockingtoni</i> .	
New species: <i>Synalpheus paulsonoides</i> , <i>S. latastei</i> , <i>S. apioceros</i> , <i>S. townsendi</i> , <i>S. fritzmülleri</i> , <i>S. hemphilli</i> , <i>S. nobilii</i> , <i>S. sanlucasi</i> , <i>S. digueti</i> , <i>S. goodei</i> , <i>S. sanctithomæ</i> , <i>S. grampusi</i> , <i>S. pandionis</i> , <i>S. brooksi</i> , <i>S. herricki</i> , <i>S. pectiniger</i> , <i>S. androsi</i> , <i>S. rathbunæ</i> , <i>S. paraneptunus</i> , <i>S. albatrossi</i> , <i>S. merospiniger</i> , <i>S. trionychis</i> , <i>S. bakeri</i> , <i>S. physoscheles</i> , <i>S. otiosus</i> , <i>S. mushaensis</i> , <i>S. maccullochi</i> , <i>S. lophodactylus</i> , <i>S. sladeni</i> .	
New subspecies: <i>Synalpheus apioceros sanjosei</i> , <i>S. a. mayaguensis</i> , <i>S. a. leiopes</i> , <i>S. a. desterroensis</i> , <i>S. paulsoni liminaris</i> , <i>S. p. senegambiensis</i> .	
CUSHMAN, JOSEPH A. Ammodiscoides, a New Genus of Arenaceous Foraminifera.—No. 1676. May 13, 1909 <sup>a</sup> . . . . .	423-424
New genus: <i>Ammodiscoides</i> .	
New species: <i>Ammodiscoides turbinatus</i> .	
EVERMANN, BARTON WARREN. See under Jordan, David Starr . . . . .	165-172
GAY, M. E. See under Holmes, S. J. . . . .	375-379
GIDLEY, JAMES WILLIAMS. Notes on the Fossil Mammalian Genus <i>Ptilodus</i> , with Descriptions of New Species.—No. 1689. June 19, 1909 <sup>a</sup> . . . . .	611-626
New species: <i>Ptilodus gracilis</i> .	



GILMORE, CHARLES W. Osteology of the Jurassic Reptile <i>Camptosaurus</i> , with a Revision of the Species of the Genus, and Descriptions of Two New Species.—No. 1666. April 17, 1909 <sup>a</sup> .....	197-332
New species: <i>Camptosaurus depressus</i> , <i>C. browni</i> .	
HAY, OLIVER P. Description of Two Species of Fossil Turtles, <i>Toxochelys stenopora</i> and <i>Chisternon? interpositum</i> , the latter hitherto Unknown.—No. 1665. April 8, 1909 <sup>a</sup> .....	191-196
New species: <i>Chisternon? interpositum</i> .	
———. On the Skull and the Brain of <i>Triceratops</i> , with Notes on the Brain-cases of <i>Iguanodon</i> and <i>Megalosaurus</i> .—No. 1660. February 6, 1909 <sup>a</sup> .....	95-108
HOLMES, S. J., and M. E. GAY. Four New Species of Isopods from the Coast of California.—No. 1670. April 27, 1909 <sup>a</sup> .....	375-379
New species: <i>Ancinus granulatus</i> , <i>Tylos punctatus</i> , <i>Actoniscus tuberculatus</i> , <i>Philoscia richardsonæ</i> .	
JORDAN, DAVID STARR, and BARTON WARREN EVERMANN. Descriptions of Three New Species of Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the Great Lakes of America; with a Note on the Species of Whitefish.—No. 1662. March 3, 1909 <sup>a</sup> .....	165-172
New species: <i>Argyrosomus eriensis</i> , <i>A. huronius</i> , <i>A. zenithicus</i> .	
——— and JOHN OTTERBEIN SNYDER. Description of a New Whitefish ( <i>Coregonus oregonius</i> ) from McKenzie River, Oregon.—No. 1677. May 15, 1909 <sup>a</sup> .....	425-430
New species: <i>Coregonus oregonius</i> .	
LYON, MARCUS WARD, Jr. A New Squirrel from Direction Island, South China Sea.—No. 1686. June 7, 1909 <sup>a</sup> ....	509-510
New species: <i>Sciurus director</i> .	
———. Additional Notes on Mammals of the Rhio-Linga Archipelago, with Descriptions of New Species and a Revised List.—No. 1684. June 1, 1909 <sup>a</sup> .....	479-491
New species: <i>Ratufa bulana</i> , <i>Mus chombolis</i> , <i>Galeopterus chombolis</i> .	
———. Remarks on the Insectivores of the Genus <i>Gymnura</i> .—No. 1680. May 27, 1909 <sup>a</sup> .....	449-456
New subspecies: <i>Gymnura gymnura minor</i> .	
MASON, OTIS T. Anyam gila (Mad Weave): A Malaysian Type of Basket Work.—No. 1672. May 6, 1909 <sup>a</sup> .....	385-390

	Page.
MEARNS, EDGAR ALEXANDER. Additions to the List of Philippine Birds, with Descriptions of New and Rare Species.—No. 1679. May 22, 1909 <sup>a</sup> .....	435-447
New species: <i>Phapitreron samarensis</i> , <i>Muscadivores palmasensis</i> , <i>Otus steerei</i> , <i>Prioniturus malindangensis</i> , <i>Yungipicus siasiensis</i> , <i>Cryptolopha malindangensis</i> , <i>Pseudotharrhaleus malindangensis</i> , <i>Brachypteryx malindangensis</i> , <i>Pyrhula steerei</i> , <i>Chibia cagayanensis</i> .	
New subspecies: <i>Rhinomyias ruficauda mindanensis</i> , <i>Hyloterpe apoensis basilanica</i> , <i>Zosterops goodfellowi malindangensis</i> , <i>Cyrtostomus jugularis mindanensis</i> , <i>C. j. woodi</i> , <i>Dicrurus baliassius mindorensis</i> .	
———. A List of Birds collected by Dr. Paul Bartsch in the Philippine Islands, Borneo, Guam, and Midway Island, with Descriptions of Three New Forms.—No. 1683. May 27, 1909 <sup>a</sup> .....	463-478
New species: <i>Collocalia bartschi</i> .	
New subspecies: <i>Ramphalcyon capensis smithi</i> , <i>Pycnonotus goiavier suluensis</i> .	
PALMER, WILLIAM. Description of a New Species of Leatherback Turtle from the Miocene of Maryland.—No. 1669. April 27, 1909 <sup>a</sup> .....	369-373
New species: <i>Psephophorus calvertensis</i> .	
REHN, JAMES A. G. On Brazilian Grasshoppers of the Subfamilies Pyrgomorphinae and Locustinae (Acridinae of Authors).—No. 1661. March 3, 1909 <sup>a</sup> .....	109-163
New name: <i>Polychitonacris</i> .	
New genera: <i>Coryacris</i> , <i>Helionotus</i> , <i>Callonotacris</i> , <i>Machæropoles</i> .	
New species: <i>Coryacris diversipes</i> , <i>Æolacris bella</i> , <i>Tropinotus attenuatus</i> , <i>Helionotus mirabilis</i> , <i>Elwochlora humilis</i> , <i>E. pulchella</i> , <i>Callonotacris lophophora</i> , <i>Zoniopoda mimicula</i> , <i>Oxybleptella pulchella</i> , <i>Inusia bonitensis</i> , <i>Mastusia koebelei</i> , <i>Paraleuas frater</i> , <i>Jodacris fuscillata</i> , <i>Leptomerinthoprora æqualis</i> , <i>Machæropoles rostratus</i> , <i>Homalosaparus sordidatus</i> , <i>Parascopas chapadensis</i> .	
RICHARDSON, HARRIET. Description of a New Isopod of the Genus <i>Jæropsis</i> from Patagonia.—No. 1675. May 13, 1909 <sup>a</sup> .....	421-422
New species: <i>Jæropsis patagoniensis</i> .	
———. The Isopod Crustacean <i>Acanthoniscus spiniger</i> Kinahan redescribed.—No. 1678. May 15, 1909 <sup>a</sup> .....	431-434
———. The Isopod Crustacean, <i>Ancinus depressus</i> (Say).—No. 1663. March 3, 1909 <sup>a</sup> .....	173-177
ROBBINS, W. W., and T. D. A. COCKERELL. Notes on Two Slugs of the Genus <i>Veronicella</i> .—No. 1671. April 27, 1909 <sup>a</sup> .....	381-384

<sup>a</sup> Date of publication.

SNODGRASS, ROBERT EVANS. The Thorax of Insects and the Articulation of the Wings.—No. 1687. June 18, 1909 <sup>a</sup> .....	511-595
SNYDER, JOHN OTTERBEIN. Descriptions of New Genera and Species of Fishes from Japan and the Riu Kiu Islands.—No. 1688. June 18, 1909 <sup>a</sup> .....	597-610
New genera: <i>Expedio</i> , <i>Inu</i> .	
New species: <i>Siphostoma yoshi</i> , <i>Ichthyocampus nox</i> , <i>Microphis ocellatus</i> , <i>Apogonichthys nafa</i> , <i>Abudefduf richardsoni</i> , <i>A. rex</i> , <i>Callyodon bowersi</i> , <i>C. adema</i> , <i>Dactyloptena gilberti</i> , <i>Zonogobius boreus</i> , <i>Expedio parvulus</i> , <i>Inu koma</i> , <i>I. ama</i> , <i>Trulla itina</i> .	
———. See under Jordan, David Starr .....	425-430
SPRINGER, FRANK. A New American Jurassic Crinoid.—No. 1664. March 3, 1909 <sup>a</sup> .....	179-190
New species: <i>Isocrinus knighti</i> .	
STEJNEGER, LEONHARD. Description of a New Snake from Panama.—No. 1681. May 27, 1909 <sup>a</sup> .....	457-458
New species: <i>Mesopeltis longifrenis</i> .	
WEED, ALFRED C. See under Bean, Barton A .....	459-461
———. See under Bean, Barton A .....	677-680
WILSON, CHARLES BRANCH. Dragonflies of the Mississippi Valley collected during the Pearl Mussel Investigations on the Mississippi River, July and August, 1907.—No. 1692. June 19, 1909 <sup>a</sup> .....	653-671

<sup>a</sup> Date of publication.





# LIST OF ILLUSTRATIONS.

## PLATES.

Facing page.

1. Skulls of Triceratops.....	108
2. Skulls of Triceratops.....	108
3. Brain casts of Triceratops.....	108
4. <i>Isocrinus knighti</i> Springer.....	190
5. Skeleton of <i>Toxochelys stenopora</i> .....	196
6. Map of Quarry 13, near Como, Wyoming.....	304
7. Anterior portion of skull of <i>Camptosaurus amplus</i> .....	306
8. Posterior part of skull of <i>Camptosaurus amplus</i> .....	308
9. Posterior part of skull of <i>Camptosaurus amplus</i> .....	310
10. Posterior part of skull of <i>Camptosaurus dispar</i> .....	312
11. Occipital region of skull of <i>Camptosaurus dispar</i> .....	314
12. Neck and part of skull of <i>Camptosaurus dispar</i> .....	316
13. Sacrum of <i>Camptosaurus dispar</i> .....	318
14. Iliia of three species of <i>Camptosaurus</i> .....	320
15. Pelvic arch of <i>Camptosaurus dispar</i> .....	322
16. Pelvic arch of <i>Camptosaurus medius</i> .....	324
17. Right hind foot of <i>Camptosaurus amplus</i> .....	326
18. Restoration of <i>Camptosaurus dispar</i> .....	328
19. Mounted skeleton of <i>Camptosaurus nanus</i> .....	330
20. Section of Jurassic exposures, near Medicine Bow, Wyoming.....	332
21. Tibetan rosary of shell beads.....	360
22. Tibetan and Mohammedan rosaries.....	360
23. Chinese official Su-chu.....	360
24. Chinese official Su-chu.....	360
25. Japanese rosaries.....	360
26. Japanese rosaries.....	360
27. Mohammedan rosaries.....	360
28. Roman Catholic rosaries.....	360
29. Roman Catholic rosaries.....	360
30. Roman Catholic rosaries.....	360
31. A new species of leather-back turtle.....	374
32. Two slugs of the genus <i>Veronicella</i> .....	384
33. A new genus of <i>Arenaceous Foraminifera</i> .....	424
34. Skins of the three forms of <i>Gymnura</i> .....	456
35. Skulls of the three forms of <i>Gymnura</i> .....	456
36. Skulls of the genera <i>Hylomys podogymnura</i> .....	456
37. External appearance of <i>Podogymnura</i> and <i>Hylomys</i> .....	456
38. Dorsal view of <i>Dactylobatus armatus</i> .....	459
39. Skulls of clawless otters.....	492
40. Thorax and base of wing of mayflies.....	596

	Facing page.
41. Prothorax of dragonflies.....	596
42. Mesothorax and metathorax of dragonflies.....	596
43. Segments of centipedes and thorax of orthoptera.....	596
44. Thorax of orthoptera.....	596
45. Microthorax and thorax of orthoptera.....	596
46. Thorax of orthoptera.....	596
47. Wings of orthoptera.....	596
48. Wings of orthoptera.....	596
49. Thorax of grasshopper and stoneflies.....	596
50. Thorax of stonefly, bark-louse, and giant water-bug.....	596
51. Thorax of giant water-bug and earwig, and microthorax of beetle.....	596
52. Thorax of earwig and beetles.....	596
53. Mesopleurum and metapleurum of beetles.....	596
54. Metapleurum of beetles.....	596
55. Mesotergum of beetles.....	596
56. Metatergum of beetles.....	596
57. Metatergum of beetles.....	596
58. Metatergum of beetle, mesotergum and metatergum of dobson-fly.....	596
59. Thorax of dobson-fly, caddice-fly, and carpenter-moth.....	596
60. Thorax of carpenter-moth and sphinx-moth.....	596
61. Thorax of sphinx-moth and hymenoptera.....	596
62. Thorax of hymenoptera and crane-fly.....	596
63. Thorax of crane-fly and horse-fly.....	596
64. Wing bases of dragonfly and stonefly, and wings of stonefly.....	596
65. Wing bases of orthoptera.....	596
66. Wing bases of giant water-bug and beetles.....	596
67. Wing bases of beetles and dobson-fly.....	596
68. Wing bases of moths and hymenoptera.....	596
69. Wing bases of hymenoptera and flies.....	596
70. <i>Ptilodus gracilis</i> Gidley.....	626

## TEXT FIGURES.

	Page.
<i>Synalpheus lockingtoni</i> . Frontal and antennal region; carpocerite; large chela; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; telson.....	21
<i>Synalpheus paulsoni</i> . Frontal and antennal region; carpocerite; portion of third foot.....	23
<i>Synalpheus paulsoni kurracheensis</i> . Frontal and antennal region; carpocerite; large chela; foot of second pair; meropodite of third pair.....	23
<i>Synalpheus hululensis</i> . Frontal and antennal region; carpocerite; telson.....	24
<i>Synalpheus tumidomanus</i> . Frontal and antennal region; carpocerite; telson..	24
<i>Synalpheus paulsonoides</i> . Frontal and antennal region; carpocerite; meropodite of third foot.....	25
<i>Synalpheus latastei</i> . Frontal and antennal region, male, Australia; frontal and antennal region, female, Chile; carpocerite; large chela; small cheliped of first pair; foot of second pair; foot of third pair.....	26
<i>Synalpheus latastei tenuispina</i> . Frontal and antennal region; carpocerite; large chela; small cheliped of first pair; foot of second pair; meropodite of third pair.....	27
<i>Synalpheus apioceros</i> . Frontal and antennal region; carpocerite; large chela; carpus of large cheliped; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; telson.....	28



<i>Synalpheus apioceros sanjosei</i> . Frontal and antennal region; spine of large chela; carpus of large cheliped; small cheliped of first pair; meropodite of third pair.....	29
<i>Synalpheus apioceros mayaguensis</i> . Frontal and antennal region; spine of large chela; dactyl of third pair; telson.....	30
<i>Synalpheus apioceros leiopes</i> . Frontal and antennal region; spine of large chela; portion of third foot.....	30
<i>Synalpheus apioceros desterroensis</i> . Frontal and antennal region; spine of large chela; carpus of large cheliped; small cheliped of first pair; meropodite of third pair.....	31
<i>Synalpheus townsendi</i> . Frontal and antennal region; carpocerite; large chela; carpus and meropodite of large cheliped; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; telson.....	32
<i>Synalpheus townsendi productus</i> . Frontal and antennal region.....	32
<i>Synalpheus townsendi brevispinis</i> . Frontal and antennal region; carpocerite; large chela; dactyl of third pair; telson.....	33
<i>Synalpheus townsendi mexicanus</i> . Frontal and antennal region; dactyl of third pair; telson.....	33
<i>Synalpheus fritzmuelleri</i> . Frontal and antennal region; carpocerite; large chela; carpus and meropodite of large cheliped; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; reverse of same; telson..	36
<i>Synalpheus fritzmuelleri elongatus</i> . Frontal and antennal region.....	37
<i>Synalpheus hemphilli</i> . Foot of third pair, Bermudas; extremity of foot of third pair, Albatross station no. 2409.....	38
<i>Synalpheus hemphilli longicornis</i> . Frontal and antennal region; extremity of third foot.....	39
<i>Synalpheus nobilii</i> . Frontal and antennal region; carpocerite; large chela; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair.....	40
<i>Synalpheus sanlucasi</i> . Frontal and antennal region; large chela; foot of second pair; foot of third pair; dactyl of third pair.....	41
<i>Synalpheus heroni</i> . Frontal and antennal region; large chela; small cheliped of first pair; foot of second pair; foot of third pair.....	43
<i>Synalpheus minus</i> . Frontal and antennal region, typical; frontal and antennal region specimen from Bermudas with basicerite spinous above; frontal and antennal region, specimen from station no. 7123 with carpocerite more slender; carpocerite, typical; carpocerite, male, station no. 7123; carpocerite, female, station no. 7123; egg; outer maxilliped; large chela, typical; small cheliped of first pair; <i>S. brevicarpus</i> ; small cheliped of first pair, typical; small cheliped of first pair, typical (another specimen); foot of second pair; foot of third pair, typical; foot of third pair, <i>S. brevicarpus</i> ; foot of third pair, station no. 7123; dactyl of third pair, not typical; dactyl of third pair, typical; telson, <i>S. brevicarpus</i> ; telson, typical.....	44
<i>Synalpheus minus bahiensis</i> . Frontal and antennal region; small cheliped of first pair; dactyl of third pair.....	45
<i>Synalpheus minus antillensis</i> . Frontal and antennal region; large chela; small cheliped of first pair; dactyl of third pair.....	46
<i>Synalpheus digueti</i> and <i>S. digueti ecuadorensis</i> . Frontal and antennal region of <i>S. digueti</i> , male of medium size; frontal and antennal region of <i>S. digueti</i> , female of medium size; frontal and antennal region of <i>S. digueti</i> , female of large size; frontal and antennal region of <i>S. digueti ecuadorensis</i> , male; carpocerite of <i>S. digueti</i> , male; carpocerite of <i>S. digueti</i> , female; carpocerite of <i>S. digueti ecuadorensis</i> ; small cheliped of first pair of <i>S. digueti</i> , meropodite of third pair of <i>S. digueti</i> .....	49

	Page.
<i>Synalpheus brevicarpus</i> . Frontal and antennal region; carpocerite; egg; large chela; small cheliped of first pair, male; small cheliped of first pair, male, <i>S. minus</i> ; foot of second pair; foot of third pair; dactyl of third pair; telson; telson, <i>S. minus</i> .....	51
<i>Synalpheus brevicarpus guerini</i> . Frontal and antennal region; front; carpocerite.....	52
<i>Synalpheus longicarpus</i> . Frontal and antennal region, male and female; carpocerite; large chela; carpus and meropodite of large cheliped; small cheliped of first pair, male and female; fingers of small cheliped of first pair; foot of second pair, male and female; foot of third pair, male and female; dactyl of third pair; dactyl of third pair of a very adult specimen; first pleopod; fourth pleopod; fifth pleopod; telson; telson and uropods, female; uropod.....	54
<i>Synalpheus longicarpus approxima</i> . Frontal and antennal region; carpocerite; large chela; small cheliped of first pair of a young specimen; small cheliped of first pair of an adult; meropodite of third foot; telson.....	56
<i>Synalpheus goodiei</i> . Frontal and antennal region, male and female; carpocerite of a young specimen; large chela; large chela of a young specimen; small cheliped of first pair; small cheliped of first pair of a young specimen; fingers of small cheliped of first pair; foot of second pair; foot of third pair; meropodite of third foot of a young specimen; dactyl of third foot; telson; uropod, male and female.....	58
<i>Synalpheus goodiei occidentalis</i> . Frontal and antennal region; frontal and antennal region; large chela; small cheliped of first pair; foot of third pair; uropods.....	60
<i>Synalpheus sanctithomae</i> . Frontal and antennal region; large chela, male and female; carpus and meropodite of large cheliped, male and female; small cheliped of first pair, male and female; foot of second pair; foot of third pair; telson; uropod.....	62
<i>Synalpheus grampusi</i> . Frontal and antennal region, male, anomalous specimen; large cheliped; small cheliped of first pair; foot of second pair; foot of third pair, male and female; telson; uropod.....	63
<i>Synalpheus parvifiti</i> . Frontal and antennal region; large chela and carpus; carpus and meropodite of large cheliped; foot of third pair; dactyl of third pair; telson; uropod.....	65
<i>Synalpheus lavimanus</i> . Frontal and antennal region; male and female; frontal and antennal region, male with rudimentary scale; frontal and antennal region, male intermediate; large cheliped; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; telson; uropod.....	66
<i>Synalpheus pandionis</i> . Frontal and antennal region; carpocerite, male and female; large chela; small cheliped of first pair; foot of second pair; foot of third pair, male and female; telson.....	68
<i>Synalpheus pandionis extensus</i> . Frontal and antennal region; carpocerite.....	69
<i>Synalpheus brooksi</i> . Frontal and antennal region, male and female; carpocerite, male and female; egg of normal size; egg of abnormal size from female; eggs of abnormal size from female; large chela; large chela, female; large chela, anomalous; large chela, anomalous, female; carpus and meropodite of large cheliped; small cheliped of first pair, male and female; fingers of small cheliped of first pair; foot of second pair; foot of third pair; meropodite of third pair; dactyl of third pair; telson, male and female; extremity of telson; uropod.....	70
<i>Synalpheus brooksi strepsiceros</i> . Frontal and antennal region; carpocerite; small cheliped of first pair; foot of second pair.....	72
<i>Synalpheus brooksi cleutheræ</i> . Carpocerite; large chela; female; small cheliped; meropodite of third pair.....	72

<i>Synalpheus herricki</i> . Frontal and antennal region, male and female; frontal and antennal region of another male; carpoperite, male and female; large chela; carpus and meropodite of large chela; small cheliped of first pair, male and female; fingers of small chela of first pair; foot of second pair, male and female; foot of third pair, male and female; dactyl of third pair of typical male; dactyl of third pair of another male; telson; male and female; uropod.....	75
<i>Synalpheus herricki angustipes</i> . Large chela; small cheliped of first pair.....	76
<i>Synalpheus herricki dimidiatus</i> . Large chela; small cheliped of first pair.....	76
<i>Synalpheus tanneri</i> . Frontal and antennal region; carpoperite; large chela; small cheliped of first pair; foot of second pair; foot of third pair.....	77
<i>Synalpheus pectiniger</i> . Anterior half, female; frontal and antennal region, male; large cheliped; small cheliped of first pair, male and female; fingers of small cheliped of first pair; reverse of same; foot of second pair, male and female; foot of third pair, male and female; dactyl of third pair; telson, male and female.....	79
<i>Synalpheus pectiniger</i> . Abdomen.....	81
<i>Synalpheus androsi</i> . Frontal and antennal region; large chela; small cheliped of first pair; foot of third pair; dactyl of third pair; carpus and meropodite of third pair; telson.....	83
<i>Synalpheus rathbunæ</i> . Frontal and antennal region; large chela; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; telson; uropod.....	84
<i>Synalpheus paraneptunus</i> . Frontal and antennal region of type male; front and base of antennæ of another male with antennal scale more reduced; front and base of antennæ of female with antennal scale absent; large chela; meropodite and carpus of large cheliped; small cheliped of first pair; finger of same; foot of second pair; foot of third pair; dactyl of third pair; telson; uropod, male and female.....	86
<i>Synalpheus neptunus</i> . Frontal and antennal region of a type male; frontal and antennal region of another type male with basicerite more spinous; front; large chela; carpus and meropodite of large cheliped; small chela of first pair; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair; telson; uropods.....	88
<i>Synalpheus albatrossi</i> . Frontal and antennal region; large chela; carpus and meropodite of large cheliped; small cheliped of first pair; foot of second pair; foot of third pair; dactyl of third pair.....	89
<i>Coryacris diversipes</i> . Lateral view of male type.....	112
<i>Coryacris diversipes</i> . Dorsal outline of head and pronotum.....	113
<i>Æolacris bella</i> . Lateral view of type.....	115
<i>Æolacris bella</i> . Dorsal outline of head and pronotum of type.....	116
<i>Æolacris bella</i> . Tegmen and wing.....	117
<i>Tropinotus attenuatus</i> . Lateral view of female type.....	119
<i>Tropinotus attenuatus</i> . Dorsal outline of head and pronotum.....	119
<i>Helionotus mirabilis</i> . Dorsal view of male type.....	122
<i>Helionotus mirabilis</i> . Lateral view of male type.....	122
<i>Helionotus mirabilis</i> . Lateral view of female type.....	123
<i>Elæochlora humilis</i> . Lateral view of type.....	125
<i>Elæochlora humilis</i> . Dorsal outline of head and pronotum of type.....	125
<i>Elæochlora pulchella</i> . Lateral view of type.....	127
<i>Elæochlora pulchella</i> . Dorsal view of head and pronotum of type.....	127
<i>Callonotacris lophophora</i> . Lateral view of male type.....	129
<i>Callonotacris lophophora</i> . Lateral view of female type.....	130
<i>Callonotacris lophophora</i> . Dorsal outline of head and pronotum of male type..	131



	Page.
<i>Callonotacris lophophora</i> . Dorsal outline of head and pronotum of female type.	131
<i>Zoniopoda mimicula</i> . Lateral view of type	132
<i>Zoniopoda mimicula</i> . Dorsal outline of head and pronotum	133
<i>Oxybleptella pulchella</i> . Lateral view of female type	137
<i>Oxybleptella pulchella</i> . Dorsal outline of head and pronotum of male	138
<i>Oxybleptella pulchella</i> . Dorsal outline of head and pronotum of female	138
<i>Inusia bonitensis</i> . Lateral view of type	140
<i>Inusia bonitensis</i> . Dorsal outline of head and pronotum of type	140
<i>Mastusia koebelei</i> . Dorsal view of female type	143
<i>Mastusia koebelei</i> . Lateral outline of head and pronotum of female type	143
<i>Paraleuas frater</i> . Lateral view of the female type	145
<i>Paraleuas frater</i> . Dorsal outline of head and pronotum of female type	145
<i>Jodacris furcillata</i> . Lateral view of male type	147
<i>Jodacris furcillata</i> . Dorsal outline of apex of male abdomen	148
<i>Leptomerinthoprora æqualis</i> . Lateral view of type	150
<i>Leptomerinthoprora æqualis</i> . Dorsal outline of head and pronotum of type	151
<i>Machæropoles rostratus</i> . Lateral view of male type	153
<i>Machæropoles rostratus</i> . Dorsal outline of head and pronotum of male type	153
<i>Homalosaparus sordidatus</i> . Lateral view of male type	155
<i>Homalosaparus sordidatus</i> . Dorsal outline of head and pronotum of male	156
<i>Parascopas chapadensis</i> . Lateral view of male type	160
<i>Parascopas chapadensis</i> . Dorsal view of apex of male abdomen	160
<i>Argyrosomus cricensis</i>	165
<i>Argyrosomus huronius</i>	168
<i>Argyrosomus zenithicus</i>	170
<i>Ancinus depressus</i>	175
<i>Ancinus depressus</i> . Maxilliped	176
<i>Ancinus depressus</i> . Mandible	176
<i>Ancinus depressus</i> . First pair of legs of female	176
<i>Ancinus depressus</i> . First and second pleopod	176
<i>Ancinus depressus</i> . Third pleopod	176
<i>Ancinus depressus</i> . Fourth pleopod	177
<i>Ancinus depressus</i> . Fifth pleopod. Outer branch	177
<i>Ancinus depressus</i> . Fifth pleopod. Inner branch	177
<i>Toxochelys stenopora</i> . Plastron. Entoplastron; epiplastron; hyoplastron; hypoplastron; xiphiplastron	193
<i>Chisternon? interpositum</i> . Part of carapace. First costal plate; third costal plate; neural plate; first neural plate; fourth neural plate; first peripheral; preneural bone	194
<i>Chisternon? interpositum</i> . Part of plastron. Entoplastron; epiplastron; hyoplastron; hypoplastron; mesoplastron; fifth peripheral	195
Map of Quarry 13	200
Skull of <i>Camptosaurus</i> . Seen from the left side	205
Skull of <i>Camptosaurus</i> . Seen from the top	205
Posterior view of occipital region of skull of <i>Camptosaurus dispar</i> Marsh	207
Lateral view of posterior portion of skull of <i>Camptosaurus dispar</i> Marsh	210
Outline of left premaxillary of <i>Camptosaurus medius</i> Marsh	214
Lateral view of left maxillary of <i>Camptosaurus</i>	215
External view of left dentary, <i>Camptosaurus</i>	219
Tenth upper tooth; fifth lower tooth of <i>Camptosaurus medius</i> Marsh	222
Internal view of right dentary, <i>Camptosaurus dispar?</i> Marsh	223
Axis and portion of atlas of <i>Camptosaurus dispar</i> Marsh	226

	Page.
Ventral view of atlas and axis of <i>Camptosaurus dispar</i> Marsh.....	227
Left lateral, ventral and anterior aspects of the axis of an <i>Orthopodus?</i> dinosaur from the Wealden of the Isle of Wight.....	228
Eighth cervical vertebra of <i>Camptosaurus browni</i> .....	230
Third dorsal vertebra of <i>Camptosaurus browni</i> .....	232
Thirteenth dorsal vertebra of <i>Camptosaurus browni</i> .....	233
Sacrum of <i>Camptosaurus browni</i> .....	240
Second caudal vertebra of <i>Camptosaurus browni</i> .....	241
Posterior caudal vertebrae with chevrons, <i>Camptosaurus browni</i> .....	242
Anterior chevron of <i>Camptosaurus dispar</i> Marsh.....	244
Eighth cervical rib of left side <i>Camptosaurus browni</i> .....	245
Posterior view of articulated scapula and coracoid of <i>Camptosaurus dispar</i> Marsh.....	247
Left scapula of <i>Camptosaurus browni</i> .....	248
Left coracoid of <i>Camptosaurus browni</i> .....	248
Left humerus of <i>Camptosaurus browni</i> .....	249
Left humerus of <i>Camptosaurus browni</i> .....	249
Right radius, ulna, and manus of <i>Camptosaurus browni</i> .....	250
Right fore foot, <i>Camptosaurus dispar</i> Marsh.....	252
Left ilium of <i>Camptosaurus dispar</i> Marsh.....	256
Left ilium of <i>Camptosaurus browni</i> .....	257
Ischia of <i>Camptosaurus medius</i> Marsh.....	258
Left pubis of <i>Camptosaurus dispar</i> Marsh.....	259
Right femur of <i>Camptosaurus dispar</i> Marsh.....	260
Right tibia and astragulus of <i>Camptosaurus dispar</i> Marsh.....	261
Right hind foot, <i>Camptosaurus dispar</i> Marsh.....	264
Pelvic arch of <i>Camptosaurus</i> ( <i>Camptonotus</i> ) <i>dispar</i> Marsh.....	271
Lateral and front views of first sacral centrum <i>Camptosaurus dispar</i> Marsh.....	274
Ungual of first digit, <i>Camptosaurus amplius</i> Marsh.....	277
Sacrum of <i>Camptosaurus nanus</i> Marsh.....	281
Right scapula and coracoid (reversed) of <i>Camptosaurus nanus</i> Marsh.....	282
Right humerus, radius and ulna <i>Camptosaurus nanus</i> Marsh.....	283
Right femur <i>Camptosaurus nanus</i> Marsh.....	284
The last dorsal or sacro-dorsal and sacrum of <i>Camptosaurus prestwichii</i> .....	287
Left femur of <i>Camptosaurus leedsii</i> Lydekker.....	290
Anterior portion of right ilium of <i>Camptosaurus depressus</i> .....	293
Left ilium of <i>Camptosaurus depressus</i> .....	293
Anterior portion of right ilium of <i>Camptosaurus depressus</i> .....	294
Section of quarry 13.....	298
<i>Ancinus granulatus</i> . First gnathopod.....	375
<i>Ancinus granulatus</i> . Second leg, second pleopod of the male.....	376
<i>Tylos punctatus</i> .....	376
<i>Tylos punctatus</i> . Antenna; first maxilla; maxilliped; second pleopod of the male; fourth pleopod; uropod.....	377
<i>Actoniscus tuberculatus</i> .....	378
<i>Philoscia richardsonæ</i> .....	378
Method of beginning mad weave.....	387
Method of adding additional strips.....	387
Result of adding new strips in three directions.....	388
Figure 3 dissected (inside).....	388
Position of sinistral strip; position of sinistral strip; position of dextral strip; position of dextral strip; position of vertical strip; position of vertical strip..	388

	P	20.
Method of giving hexagonal form to base at upset.....	389	
Method of finishing at the border, with two hoops of rattan.....	389	
Method of turning strips at the border, polished side out.....	389	
Method of turning vertical strips at the border, polished side out.....	389	
Method of finishing at the border.....	390	
Method of ornamentation.....	390	
Radials, basals, and infrabasals of <i>Hypalocrinus naresianus</i> .....	409	
<i>Ieropsis patagoniensis</i> .....	421	
<i>Coregonus oregonius</i> .....	428	
<i>Acanthoniscus spiniger</i> .....	432	
<i>Acanthoniscus spiniger</i> . Second antenna.....	432	
<i>Acanthoniscus spiniger</i> . Uropod.....	433	
<i>Acanthoniscus spiniger</i> . Maxilliped.....	433	
<i>Acanthoniscus spiniger</i> . Second maxilla.....	433	
<i>Acanthoniscus spiniger</i> . First maxilla, inner lobe, outer lobe.....	434	
<i>Acanthoniscus spiniger</i> . Anterior view of head showing epistome with labrum.....	434	
Diagram to show to relative sizes of the three forms in the genus <i>Gymnura</i> as determined by length of hind foot, including claws, and of basal length of skull.....	452	
Outline of ventral surface of <i>Dactylobatus armatus</i> .....	460	
Diagrammatic tergum of any complete wing-bearing segment, and the base of the wing; dorsal view.....	523	
Diagrammatic tergum of any complete wing-bearing segment; ventral view...	524	
Diagrammatic lateral view of any complete wing-bearing segment, external...	536	
Diagrammatic view of inner surface of the pleurum of any complete wing-bearing segment.....	537	
Diagram of a generalized wing and its articular sclerites or axillaries.....	544	
Diagrammatic cross section of a wing-bearing segment.....	544	
Left humerus of <i>Ptilodus gracilis</i> .....	620	
Right radius of <i>Ptilodus gracilis</i> .....	620	
Terminal phalanx of <i>Ptilodus gracilis</i> .....	621	
Left half of pelvis of <i>Ptilodus gracilis</i> .....	621	
Right femur of <i>Ptilodus gracilis</i> .....	621	
Proximal portions of tibia and fibula of <i>Ptilodus gracilis</i> .....	621	
Right lower jaw of <i>Trichosurus vulpecula</i> .....	624	
Right lower jaw of <i>Ptilodus gracilis</i> .....	624	
Right lower jaw of <i>Plagiaular brecklesii</i> .....	625	
<i>Spongilla sceptrioides</i> . Skeleton spicules; gemmule spicules.....	628	
<i>Spongilla philippinensis</i> . Fragment of skeleton.....	629	
<i>Spongilla philippinensis</i> . Skeleton spicules; gemmule spicule.....	630	
<i>Spongilla clementis</i> . Skeleton spicules; gemmule spicule; fragment of skeleton.....	632	
<i>Benthobatis marcida</i> .....	677	



# THE AMERICAN SPECIES OF SNAPPING SHRIMPS OF THE GENUS *SYNALPHEUS*.<sup>a</sup>

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## HISTORY OF THE AMERICAN SPECIES OF THE GENUS.

The nominal species of *Synalpheus* from the coasts of America at the present time are eight in number, of which one, *Alpheus precox* of Herrick, is a *nomen nudum*. All of them appeared at first under the generic name of *Alpheus*: *A. minus* Say (1818), *A. spinifrons* Milne Edwards (1837), *A. tridentulatus* Dana (1852), *A. saulcyi* Guérin (1856), *A. leviusculus* Lockington (1878), *A. saulcyi longicarpus* and *A. saulcyi brevicarpus* Herrick (1891).

These nominal species are so imperfectly diagnosed that I have been able to retain the names of only three of them, *Synalpheus minus* (Say), *S. brevicarpus* (Herrick), and *S. longicarpus* (Herrick). This list could have been augmented by *Alpheus leviusculus* Lockington, had it not been necessary to change the name (it having been preoccupied by Dana) to *S. lockingtoni*.

The *A. spinifrons* of Milne Edwards is from Chile. The type is lost, and I have seen no form from that region which exactly corresponds. Although Nicolet's drawing may be very imperfect with regard to the cephalic appendages, yet the scaphocerite seems to be much reduced, and this is confirmed by the text: "lámina basilar de las antenas esternas muy pegueña, sin llegar con mucho á la estremidad del pedúnculo de estos órganos." I do not believe that the species, in view of this circumstance, can be placed elsewhere than in the *LEVIMANUS* group. The small claw, it is true, is described simply "con algunas pelos," but the plume of long hairs, so characteristic of this claw in the group, could, in spite of its constancy, very easily pass unnoticed. This plume has never before been described or figured; but the unusual prevalence of the *LEVIMANUS* group on the American coasts compels me to recognize the importance of this curious, though apparently insignificant, character.

Formerly, I identified *Alpheus tridentulatus* Dana with *A. minus* Say, by reason of the short and broad form of the frontal teeth and

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<sup>a</sup> Translated from the French by Miss Mary J. Rathbun.

the slight build of the small claw. Dana's species is from Rio Janeiro, and the species of the *BREVICARPUS* group (to which *A. minus* belongs) are not as yet known to extend beyond Bahia. But that is a purely negative assumption, of very little value, and I still, as the most plausible explanation, consider that the antennal scale was accidentally omitted from Dana's drawing. The absence of this scale would suggest the *LEVIMANUS* group; but none of the species of this group have the external spine of the basicerite so short or the stylocerite so long. The exact identification of the form is, however, impossible because of the large number of closely related species and the slightness of the distinctive characters.

*Alpheus minus* is no longer represented by authentic specimens, except the two dried examples, fortunately alike, preserved in the British Museum and sent to Doctor Leach by Thomas Say himself. They can be identified with a rather common species from Florida and the Bahamas; such a determination would probably not be possible for all the specimens collected by Say, did they still exist. Another species from the same region, appearing to be even more common, is that which Herrick has described under the name of *A. sauleyi brevicarpus*, in opposition to his *A. sauleyi longicarpus*. Far from being closely allied varieties of a single species, these two forms are in reality widely separated and easily distinguished; furthermore, *S. brevicarpus*, which I had formerly considered synonymous with *S. minus* (Say), is also distinct, and each of these two species possesses several subspecies, forming a small, well-defined group which may be designated as the *BREVICARPUS* group, which, so far as is known at present, is characteristic of the American region.

I have not succeeded in identifying *Alpheus sauleyi* Guérin with any of the forms which I have studied; the species belongs obviously to the *BREVICARPUS* group, being perhaps synonymous with *S. brevicarpus* (Herrick). In Guérin's drawing the chief character which recalls this species is the narrow form of the antennules; but the frontal teeth, the scaphocerite, the superior prominence of the basicerite are very imperfectly figured. As Guérin's species is from Cuba, I should be more inclined to believe it synonymous with the new form which I have named *S. brevicarpus guerini*, which is also from the West Indies, and which in other respects appears most comparable to Guérin's figure. This resemblance is, however, much too vague for me to consider myself justified in retaining the name of *sauleyi*, in spite of my desire to do so.

As to *Alpheus longicarpus*, I have been able to examine two specimens received from Professor Herrick; because of the dissimilarity of these two specimens, I had thought it wisest to distinguish all those which corresponded to them respectively under the name of *longicarpus*  $\alpha$  and  $\beta$ , but this distinction is very far from being satisfactory; for

*S. longicarpus*  $\alpha$  belongs in reality to the group which I call the LEVIMANUS group, from the name of the Mediterranean species of Heller, a group which is characterized essentially by a brush of long stiff hairs on the movable finger of the small claw. I have been obliged to recognize eighteen species and subspecies belonging to it upon the American coast, so that the old specific limits have become greatly narrowed; I have retained the name *longicarpus* for that species which appears to be among the most widely distributed in the region of the Gulf of Mexico and the Bahamas, and which conforms to one of Herrick's types; the species has small eggs and its larvæ are zoëæ; in regard to *S. longicarpus*  $\beta$ , the specimens which I had at first grouped under that name are found to be referable to three very distinct species, each provided with numerous subspecies; that species which corresponds to the type specimen of Herrick is *S. pectiniger*, new species; the other two have received the names *S. brooksi* and *S. herricki*. All three have eggs of large size, from which spring mysis larvæ, and one of the species must certainly be Herrick's nominal species *Alpheus precox*, without its being possible to definitely determine which.

Save for the preceding exceptions, all the forms, perhaps thirty species and varieties, have had to receive new names. It is a considerable number, and surprised me at first. Although several present very strong resemblances to other forms of the eastern Atlantic, the Indian Ocean, and the Pacific islands, all are peculiar to the American coasts. This is true also of *S. lockingtoni*, which is represented in the Indian Ocean by some closely allied species, which, in turn, are difficult to separate from specimens from the Red Sea, the Mascarene Islands, and from the west coast of Africa. It would seem that these specimens represent local races of a cosmopolitan species. There is, however, a remarkable exception in *S. latastei*, Chilian specimens of which can not be distinguished from Australian.

#### CLASSIFICATION OF THE SPECIES.

In view of the growing number of species of the genus *Synalpheus*, one is led to distinguish among them several groups composed of the more closely allied forms, which may be differentiated in the following manner:

##### KEY TO THE SPECIFIC GROUPS OF THE GENUS SYNALPHEUS.

- $a^1$ . Supraorbital spines insignificant compared to the rostrum; antennules shorter than the antennæ; spines of the basicerite almost equal, the external always smaller than the stylocerite; external maxillipeds oval, feebly spinous distally; first segment of the carpus of the second pair of feet very long; following feet cylindrical; ventral hook of the dactyl obsolete; telson with an oval median lobe-----COMATULARUM group.
- $a^2$ . Supraorbital spines at least equal to the rostrum in importance; antennules at least equal to the antennæ; spines of the basicerite unequal, the exter-



- nal often larger than the stylocerite, the internal often wanting; external maxillipeds cylindrical in form, very spinous distally; first segment of the carpus of the second pair approximately equal to the sum of the remaining segments; following feet flat in the sagittal plane; ventral hook of the dactyl as large as the dorsal; posterior border of the telson almost straight.
- b*<sup>1</sup>. Dactyls of the third, fourth, and fifth feet with two unequal hooks, the ventral always stronger (up to three times greater), often accompanied by a third prominence obtuse or spinous; meropodites often spinous; frontal spines always longer than wide at the base-----NEOMERIS group.
- b*<sup>2</sup>. Dactyls with two hooks approximately equal in width at the base; meropodites smooth.
- c*<sup>1</sup>. Dactyls long and slender; hooks directed with the axis of the dactyl, little curved, the dorsal longer; scale of the scaphocerite always present; lateral spine of the basicerite slender; stylocerite longer than the basal article of the antennule.
- d*<sup>1</sup>. Frontal teeth always longer than wide and spinous; rostrum armed with a vertical prolongation which embraces the ocellary beak.  
PAULSONI group.
- d*<sup>2</sup>. Frontal teeth squarish, at most with concave margins; rostrum without inferior vertical prolongation-----BREVICARPUS group.
- c*<sup>2</sup>. Dactyls short; hooks strongly curved, the ventral directed normal to the lower border of the dactyl; scale of the scaphocerite ordinarily much reduced, often wanting; lateral spine of the basicerite always longer than the basal article of the antennulæ, thick; stylocerite short.
- d*<sup>1</sup>. Small claw with a brush of thick and crowded long hairs normal to the dactyl; stylocerite at most equal to the basal article of the antennule; carpus of the small cheliped longer than wide.  
LÆVIMANUS group.
- d*<sup>2</sup>. Small claw without a brush of hairs; stylocerite not reaching the middle of the median article of the antennule; antennal scale narrow, not reaching beyond the extremity of the same article; carpus of the small cheliped short-----BIUNGICULATUS group.

The COMATULARUM group is differentiated from the other groups by some very marked characters, which are almost all characters found in the Hippolytidae and therefore suggest a less strong resemblance to the "Reptantia;" as frequently happens, there are added to these primitive characters others which show, on the contrary, an adaptation carried very far; for instance, the strongly curved hooks and the movable finger of the small chela surpassing the fixed finger; these characters are especially marked in *S. comatularum*, and are explained by its commensalism with the Comatulida, being implements of attachment for the *Synalpheus*.

This group of very beautiful species appears not to occur on the American coast; the steamer *Albatross*, of the U. S. Bureau of Fisheries, has collected a new species of it at the Gilbert Islands, the more remarkable because it possesses only a few of the unusual characters of the group: The spines of the basicerite are equal and short, the first segment of the carpus of the second pair very long, and the following feet cylindrical. On the other hand, the antennules are equal to the antennæ, the rostrum is scarcely more prominent than the



lateral teeth, the ventral hook of the dactyls is almost as strong as the dorsal, and the telson is straight along its posterior margin—all characters not unusual in *Synalpheus*. The other groups of species vary more or less from the preceding; the nearest are the PAULSONI and BREVICARPUS groups, in which the stylocerite still remains more prominent than the external spine of the basicerite, and the antennal scale is never wanting and sometimes is very wide.

The external spine of the basicerite begins to predominate in the NEOMERIS group, but this group presents, besides, two characters of the Hippolytidae but little modified, viz, the movable spines often present on the third and fourth meropodites and the frequent triunguiculation of the dactyls of the same feet, which is a vestige of the series of spines present on the dactyl in many of the Eucyphota.

There are no more than two hooks on the short and stocky dactyl in the BIUNGUICULATUS group, of which the ventral, the more feeble, has a tendency to become normal to the lower border of the dactyl. On the other hand, the shortening of the stylocerite and of the antennal scale becomes very noticeable and the finger of the small chela of the second pair carries a brush of hairs arranged in series. The species grouped under this head are few, but they show the very gradual connection between those which precede and the LEVIMANUS group, the most highly differentiated of the Synalpheids in the direction of the "Reptantia." Here the antennal scale has very often disappeared without leaving any trace, the lateral spine of the basicerite possesses a bulk which contrasts with the slight importance of the stylocerite, and the sexual differences often become very strong, one might say exaggerated, in regard to the size of the abdomen of the female and of the large cheliped of the male; finally, the finger of the small cheliped, in which the carpus has, however, remained more elongated than in any other group, bears a curious structure composed of from fifteen to twenty transverse rows of long stiff hairs, which are normal to the dactyl, and which diminishes in length from behind forward; this brush may be a cleansing organ in connection with the very sedentary life of these species, or it may conceal from the prey the extremity of the real prehensile chela. The only comparable organ in the Alpheidae is the tuft of long plumose hairs which is borne by the chela of the second pair in *Cheirothrix parvimanus* Bate, a genus, moreover, very like *Synalpheus*.

## KEY TO THE SPECIES AND SUBSPECIES OF THE GENUS SYNALPHEUS.

## NEOMERIS group.

(Represented on the American coast only by forms with the meropodites smooth and unarmed.)

- a*<sup>1</sup>. Ventral supernumerary prominence of the third, fourth, and fifth dactyls obtuse and scarcely marked.
- b*<sup>1</sup>. All the appendages slender.
- c*<sup>1</sup>. Meropodites of the third pair four times as long as wide.
- d*<sup>1</sup>. Antennal spine equaling the carpocerite.....*S. fritzmuelleri*.
- d*<sup>2</sup>. Antennal spine surpassing the carpocerite.....*S. fritzmuelleri elongatus*.
- c*<sup>2</sup>. Meropodites of the third pair three times as long as wide.....*S. nobilii*.
- b*<sup>2</sup>. All the appendages stocky; meropodite of the third pair only 2.5 times as long as wide.....*S. sanlucasi*.
- a*<sup>2</sup>. Ventral supernumerary prominence of the third, fourth, and fifth dactyls spinous and very marked.
- b*<sup>1</sup>. Antennary spine equaling the carpocerite.....*S. hemphilli*.
- b*<sup>2</sup>. Antennary spine surpassing the carpocerite; traces of spines on the meropodites of the third pair.....*S. hemphilli longicornis*.

## PAULSONI group.

- a*<sup>1</sup>. Carpocerite long, arising opposite the separation of the stylocerite from the basal article of the antennulæ; meropodite of the third pair from 3.5 to 5 times as long as wide.
- b*<sup>1</sup>. Basicerite unarmed above, carpocerite 3.5 times as long as wide.
- c*<sup>1</sup>. Palmar prominence spinous; angles of the telson sharp, the inner spines of its posterior border 3 times longer than the outer spines.
- d*<sup>1</sup>. Rostrum at most equal to the basal article of the antennulæ; antennary spine not surpassing the carpocerite.....*S. townsendi*.
- d*<sup>2</sup>. Rostrum, frontal, and antennal spines more elongate.  
*S. townsendi productus*.
- c*<sup>2</sup>. Palmar prominence obtuse; angles of the telson right, the inner spines only twice the length of the outer.....*S. townsendi brevispinis*.
- b*<sup>2</sup>. Basicerite with a right and not obtuse superior angle; posterior angles of the telson very sharp.....*S. townsendi mexicanus*.
- b*<sup>2</sup>. Basicerite strongly spinous above; carpocerite ovoid, three times as long as wide.
- c*<sup>1</sup>. Meropodite of the third pair less than four times as long as wide.
- d*<sup>1</sup>. Dactyl of the third pair about 3.2 times as long as wide at the base.
- c*<sup>1</sup>. Carpus of the small cheliped spinous above; spine of the scaphocerite equal to the carpocerite.....*S. apioceros*.
- c*<sup>2</sup>. Carpus of the small cheliped not spinous above; spine of the scaphocerite shorter than the carpocerite.....*S. apioceros sanjosi*.
- d*<sup>2</sup>. Dactyl of the third pair 3.8 times as long as wide; carpocerite very swollen, surpassing the antennule by 1.5 times its distal article; spine of the large claw continuing in a straight line its superior border.....*S. apioceros mayaguensis*.
- c*<sup>2</sup>. Meropodite of the third pair more than four times as long as wide.
- d*<sup>1</sup>. Antennal spine longer than the antennule; rostro-orbital interval acute at base; spine of the large claw preceded by a tubercle.  
*S. apioceros leiopis*.
- d*<sup>2</sup>. Antennal spine at most equal to the antennule, rostro-orbital interval broad and sinuous at base; spine of the large claw continuing the superior border in a straight line.....*S. apioceros desterroensis*.

- a*<sup>2</sup>. Carpocerite short, arising nearly opposite the median antennular article; basal article of the antennule equal to the following, or 1.5 times as long, or more; palmar border of the large cheliped unarmed.
- b*<sup>1</sup>. Carpocerite three times as long as wide.
- c*<sup>1</sup>. Meropodite of the third pair more than 3.5 times as long as wide; large chela 2.9 times as long as high; antennal spine equal to the carpocerite ----- *S. lockingtoni*.
- c*<sup>2</sup>. Meropodite of the third pair less than 3.5 times as long as wide; large chela 2.5 times as long as high; antennal spine longer than the carpocerite, slender ----- *S. latastei tenuispina*.
- b*<sup>2</sup>. Carpocerite less than three times as long as wide; antennule thick, scarcely four times as long as wide; meropodite of the third pair three times as long as wide ----- *S. latastei*.
- b*<sup>3</sup>. Carpocerite more than three times as long as wide; meropodite slender, five times as long as wide; spine of the scaphocerite surpassing the antennule ----- *S. paulsonoides*.

## BREVICARPUS group.

- a*<sup>1</sup>. Carpocerite cylindrical, slender, at least four times as long as wide; antennal scale from 5.5 to 6.4 times as long as wide; basicerite almost unarmed above; meropodite of the third pair from 4.25 to 4.5 times as long as wide; carpus of the second pair from ten to fifteen times as long as wide; telson 2 to 2.2 times as long as wide distally.
- b*<sup>1</sup>. Lateral spine of the scaphocerite scarcely surpassing the scale; frontal teeth equilateral, short; eggs of large size, producing mysis.  
*S. brevicarpus*.
- b*<sup>2</sup>. Lateral spine of the scaphocerite long and slender; frontal teeth as long as wide at the base; rostrum with concave margins; eggs small, producing zoëæ ----- *S. brevicarpus gucrini*.
- a*<sup>2</sup>. Carpocerite swollen, from 3.5 to 3.7 times as long as wide; antennal scale from 7 to 8.5 times as long as wide; carpus of the second pair less than ten times as long as wide; meropodite of the third pair 3.4 to 4 times as long as wide; telson 1.8 times as long as wide distally; larvæ zoëæ.
- b*<sup>1</sup>. Antennules at most five times as long as wide; rostrum as long as the lateral teeth of the front.
- c*<sup>1</sup>. Frontal teeth short, equilateral.
- d*<sup>1</sup>. Superior spine of the basicerite feeble, as wide as long, that of the scaphocerite shorter than the carpocerite; small claw with elongated fingers, 2.8 times longer than wide ----- *S. minus*.
- d*<sup>2</sup>. Superior spine of the basicerite twice as long as wide, that of the scaphocerite equal to the carpocerite; small claw with short fingers, 2.6 times as long as wide ----- *S. minus bahiensis*.
- c*<sup>2</sup>. Frontal teeth long, a little concave; carpocerite very swollen, from 3.2 to 3.5 times as long as wide; scaphocerite short; hooks of the dactyls often equal ----- *S. minus antillensis*.
- b*<sup>2</sup>. Antennules more than five times as long as wide; rostrum shorter and narrower than the lateral teeth.
- c*<sup>1</sup>. Carpocerite 3.5 times, meropodite of the third pair 3.4 times, as long as wide ----- *S. digueti*.
- c*<sup>2</sup>. Carpocerite 3.2 times, meropodite 3.25 times, as long as wide.  
*S. digueti ecuadorensis*.

## LÆVIMANUS group.

- a*<sup>1</sup>. Carpus of the small cheliped measuring always more than one-half of the chela in the adult (proportion included between 0.54 and 0.8, but may be reduced to 0.5 in the young).
- b*<sup>1</sup>. Lateral spine of the basicerite smaller than that of the scaphocerite.
- c*<sup>1</sup>. Fingers of the small chela each armed with three strong flat teeth, crossed in a vertical plane; no trace of antennal scale; spine of the scaphocerite shorter than the antennule; movable finger of the chela out of the perpendicular; eggs of large size-----*S. pectiniger*.
- c*<sup>2</sup>. Fingers of the small chela with only two teeth; spine of the scaphocerite equaling the antennule.
- d*<sup>1</sup>. A trace of an antennal scale in the male; carpus of the small cheliped reaches 0.74 of the chela, diminishing to 0.5 and even a little less in the young-----*S. longicarpus*.
- d*<sup>2</sup>. An antennal scale in both sexes; carpus of the small cheliped not exceeding 0.54 in the adult males-----*S. longicarpus approxim.*
- b*<sup>2</sup>. Lateral spine of the basicerite equal to that of the scaphocerite, but both shorter than the antennule; antennal scale totally absent.
- c*<sup>1</sup>. Carpus measuring from 0.67 to 0.8 of the small chela.
- d*<sup>1</sup>. Proportion of T. L.: H.<sup>a</sup>=2.6:1 to 2.5:1; meropodite of the small cheliped 3 to 3.3 times as long as wide-----*S. herricki*.
- d*<sup>2</sup>. Proportion of T. L.: H.=2.7:1, the chela being more slender; meropodite of the small cheliped four times as long as wide.  
*S. herricki dimidiatus*.
- c*<sup>2</sup>. Carpus measuring 0.65 of the small chela; proportion of T. L.: H.=3:1-----*S. herricki angustipes*.
- c*<sup>2</sup>. Carpus measuring 0.56 of the small chela, proportion of T. L.: H.=3.2:1; carpocerite 5.4 times longer than wide (instead of 4.8 to 5); feet of second and third pairs one-fourth stronger than in the preceding forms-----*S. tanneri*.
- a*<sup>2</sup>. Carpus measuring about one-half of the small chela in the adult (0.45 to 0.52).
- b*<sup>1</sup>. A well developed antennal scale in both sexes; carpocerite 6.5 times longer than wide; meropodite of the third pair 3.8 times longer than wide; small chela slender, proportion of T. L.: H.=3.33:1.
- c*<sup>1</sup>. Spine of the basicerite and of the scaphocerite shorter than the antennule-----*S. pandionis*.
- c*<sup>2</sup>. Spines equal to the antennule-----*S. pandionis extensus*.
- b*<sup>2</sup>. No antennal spine.
- c*<sup>1</sup>. Basicerite spinous above; carpus of the second pair with four segments-----*S. rathbunæ*.
- c*<sup>2</sup>. Basicerite unarmed above.
- d*<sup>1</sup>. Large chela 2.5 times longer than wide, its anterior palmar spine directed obliquely downward; supraorbital spines wide, leaving between them and the rostrum U-shaped intervals; carpocerite 5.5 times longer than wide; meropodites of the third pair thick (proportion 3.3:1); eggs small; larvæ zoëæ-----*S. grampsi*.
- d*<sup>2</sup>. Large chela 2.7 to 3.25 times longer than wide; anterior palmar spine conical, directed obliquely upward; supraorbital spines obtuse, divergent; meropodite of the third pair slender (proportion 4.3:1 to 4.5:1); eggs of large size; larvæ mysis.

<sup>a</sup>Total length to height (of large chela).



- $c^1$ . Carpus of the small cheliped measuring 0.5 of the chela.  
 $f^1$ . Carpocerite 4.5 times as long as wide----- *S. brooksi*.  
 $f^2$ . Carpocerite 5.5 times as long as wide---- *S. brooksi strepsiceros*.  
 $e^2$ . Carpus of the small cheliped measuring 0.53 to 0.57 of the chela;  
 carpocerite 4.4 times as long as wide----- *S. brooksi cleutheræ*.  
 $a^3$ . Carpus measuring less than 0.5 of the small chela (0.43 to 0.4).  
 $b^1$ . Meropodite and carpus of the third pair excavate, with a transparent  
 outer margin----- *S. androsi*.  
 $b^2$ . Meropodite of the third pair not excavate; carpus shorter than the pro-  
 podite.  
 $c^1$ . Brush of hairs of the small chela very reduced (about 30 hairs in 6  
 rows); antennal scale present in the male only-----*S. paraneptunus*.  
 $c^2$ . Brush of hairs of large size, composed of 15 to 20 rows.  
 $d^1$ . Carpocerite 3.5 to 4 times longer than wide; meropodite of the third  
 pair 4 to 4.5 times longer than wide-----*S. sanctithomæ*.  
 $d^2$ . Carpocerite 5.2 to 6 times, meropodite 3 to 3.5 times, longer than wide.  
 $e^1$ . Antennal scale present in both sexes----- *S. goodei*.  
 $e^2$ . Antennal scale absent (or extremely narrow when it is exception-  
 ally present)----- *S. goodei occidentalis*.

## DISTRIBUTION AND DISCUSSION OF SPECIFIC CHARACTERS.

*Table of distribution of the species of the genus Synalpheus.*

## COMATULARUM GROUP.

Indo-Pacific forms.	American forms.	Mediterranean and West African forms.
<i>S. comatularum</i> Haswell. <i>S. stimpsoni</i> de Man. <i>S. stimpsoni maldivensis</i> Coutière. <i>S. carinatus</i> de Man. <i>S. amboinæ</i> Zehntner. <i>S. albatrossi</i> Coutière.		

## NEOMERIS GROUP.

<i>S. neomeris</i> de Man.	
<i>S. neomeris streptodactylus</i> Coutière.	
<i>S. nilandensis</i> Coutière. ....	<i>S. hemphilli</i> Coutière.
<i>S. nilandensis oxyceros</i> Coutière ....	<i>S. hemphilli longicornis</i> Coutière.
<i>S. graviere</i> Coutière.	
<i>S. pococki</i> Coutière.	
<i>S. merospiniger</i> Coutière. <i>a</i>	
<i>S. fossor</i> Paulson.	
<i>S. trionychis</i> Coutière.	
<i>S. triunguiculatus</i> Paulson.	
<i>S. bakeri</i> Coutière. ....	<i>S. nobilii</i> Coutière.
<i>S. physochetes</i> Coutière.	
<i>S. demani</i> Borradaile.	
<i>S. charon</i> Heller.	
<i>S. otiosus</i> Coutière.	
<i>S. paranemeris</i> Coutière. ....	<i>S. fritzmuelleri</i> Coutière.
<i>S. paranemeris prolatus</i> , new name	<i>S. fritzmuelleri elongatus</i> Coutière.
(= <i>S. paranemeris oxyceros</i> Coutière).	
<i>S. heroni</i> Coutière. ....	<i>S. santucasi</i> Coutière.

<sup>a</sup> For descriptions of this and other new extra-American species, see pages 89 to 93.

Table of distribution of the species of the genus *Synalphus*—Continued.

## PAULSONI GROUP.

Indo-Pacific forms.	American forms.	Mediterranean and West African forms.
<i>S. paulsoni</i> Nobili .....	<i>S. paulsonoides</i> Coutière.	
<i>S. paulsoni liminaris</i> Coutière.		
<i>S. paulsoni rameswarensis</i> Coutière.		
<i>S. paulsoni kurracheensis</i> Coutière..	<i>S. lockingtoni</i> , new name ( <i>A. leviusculus</i> Lockington).	
<i>S. hululensis</i> Coutière.	.....	<i>S. paulsoni senegambiensis</i> Coutière.
<i>S. tamidomanus</i> Paulson and var. <i>exilimanus</i> Paulson?		
<i>S. mushaensis</i> Coutière.		
<i>S. maccullochi</i> Coutière.....	{ <i>S. latastei</i> Coutière.	
<i>S. latastei</i> Coutière.	{ <i>S. latastei tenuispina</i> Coutière.	
<i>S. acanthitelsonis</i> Coutière.		
	<i>S. apioceros</i> Coutière.	
	<i>S. apioceros sanjosei</i> Coutière.	
	<i>S. apioceros mayaguensis</i> Coutière.	
	<i>S. apioceros leiops</i> Coutière.	
<i>S. hastilicrassus</i> Coutière.....	<i>S. apioceros desterronis</i> Coutière.	
	<i>S. townsendi</i> Coutière.	
	<i>S. townsendi productus</i> Coutière.	
	<i>S. townsendi mexicanus</i> Coutière.	
<i>S. tricuspideatus</i> (Heller).	<i>S. townsendi brevispinis</i> Coutière.	

## BREVICARPUS GROUP.

	<i>S. brevicarpus</i> (Herrick).	
	<i>S. brevicarpus guerini</i> Coutière.	
	<i>S. minus</i> (Say).	
	<i>S. minus bahiensis</i> Coutière.	
	<i>S. minus antillensis</i> Coutière.	
	<i>S. digueti</i> Coutière.	
	<i>S. digueti ecuadorensis</i> Coutière.	

## BIUNGUICULATUS GROUP.

<i>S. biunguiculatus</i> (Stimpson).		
(?) <i>S. spiniger</i> (Stimpson).		
<i>S. biunguiculatus exilips</i> Coutière.		
<i>S. biunguiculatus pachymeris</i> Coutière.		
<i>S. neptunus</i> (Dana).		
<i>S. laticeps</i> Coutière.		
<i>S. pescadorensis</i> Coutière.		
<i>S. lophodactylus</i> Coutière.		
(?) <i>S. haddoni</i> Coutière.		

## LEVIMANUS GROUP.

	<i>S. spinifrons</i> (M. Edwards). (?)	
	<i>S. longicarpus</i> (Herrick) .....	<i>S. levimanus</i> (Heller).
	<i>S. longicarpus approxima</i> Coutière.	
	<i>S. goodei</i> Coutière.	
	<i>S. goodei occidentalis</i> Coutière.	
	<i>S. pandionis</i> Coutière .....	<i>S. parfatti</i> Coutière.
	<i>S. pandionis extensus</i> Coutière.	
	<i>S. grampusi</i> Coutière.	
	<i>S. sanctithomæ</i> Coutière.	
	<i>S. brooksi</i> Coutière.	
	<i>S. brooksi strepsiceros</i> Coutière.	
	<i>S. brooksi cleutheræ</i> Coutière.	
	<i>S. herricki</i> Coutière.	
	<i>S. herricki dimidiatus</i> Coutière.	
	<i>S. herricki angustipes</i> Coutière.	
	<i>S. tanneri</i> Coutière.	
	<i>S. pectiniger</i> Coutière.	
	<i>S. androsi</i> Coutière.	
	<i>S. rathbunæ</i> Coutière.	
	<i>S. paranepentus</i> Coutière.	
<i>S. sladeni</i> Coutière.		

The preceding table shows the relative importance of the several groups inhabiting the American coasts, and enumerates, without description, all the species of the genus *Synalpheus* which are known to me. There are also included a certain number of species, yet unpublished, from other localities.

This table brings out well an important fact; that is, that the species of the PAULSONI and NEOMERIS groups, especially the former, are the most widely distributed. This distribution accords with certain unspecialized characters which are found among them, namely, the short carpocerite, the rostrum always possessing an inferior vertical prolongation, continuing the ocellary beak, and the dactyls slender and elongated. The disappearance of the rostral partition, the elongation of the carpocerite, thick or not, and the shortening of the dactylopodites indicate forms less and less allied to the Hippolytidae and more and more Synalphean.

Before examining more closely the relation of the groups of species to one another, I ought to mention that many of the forms described have received trinomial appellations and correspond consequently to what zoological nomenclature designates as varieties, races, or subspecies, and to that which the botanists know under the name of "petites espèces." In employing the trinomial name to designate certain forms allied to one another, I simply wish to say that the forms represented by these names appear to me to be less distant from the species to which I attach them than the species is from another species. Most often these subspecies come from different localities and appear also to be distinct geographical races. This is, however, probably a result of the fact that the localities cited were the only ones explored. One should not forget that the stations noticed, rather numerous in Florida and at the Bahamas, for example, are restricted to a few points on the thousands of miles of shore line along the entire Pacific coast and even on the Atlantic coast south of Florida. At other times these secondary forms, related to species easy to determine, come from the same locality as the species. This expression "same locality," in spite of its apparent precision, is most often very vague. Two closely allied forms can find upon the same reef very different conditions of life, which isolate them as completely as if a continent separated them. One species inhabiting a sponge, another living attached by its hooks upon some species of madrepore, appear to me to represent a case of this sort.

It is possible, then, that the trinomial appellation which I uniformly employ does not correspond in nature to facts exactly comparable; that certain of the "races," "subspecies," or "small species" which it serves to designate merit a distinct specific name; that others, on the contrary, may be variations incompletely fixed of a species in a state of actual instability, the limits of which it has not been possible for me to fix more completely.

To return to the groups of species of the genus *Synalpheus*, the one which I designate by the name of the *PAULSONI* group, presents a most remarkable geographical distribution. *S. paulsoni* Nobili (perhaps identical with *S. tricuspidatus* (Heller)) is a species with short carpocerite from the Red Sea and the Persian Gulf, the affinities of which are to my mind very clearly indicated; it is separated, first from the forms with carpocerite equally short, but distinguished by the spinous palm of the large chela, or by the basicerite almost unarmed above, and again from the forms with carpocerite more elongate; variation in this last direction leads to some forms with the carpocerite elongate and slender (*S. hululensis* Coutière, *S. tumidomanus* Paulson, the latter very distinct on account of its large eggs, producing mysis, and the spinous angles of the telson). In another direction there are found some forms in which the carpocerite is elongate as in those preceding, but, in addition, is swollen, and of an ovoid form (*S. acanthitelsonis* Coutière, *S. hastilicrassus* Coutière). In a third direction, finally, there are found some species differing from *S. paulsoni* by the more massive aspect of the appendages; though indicated by a form *kurracheensis*, this evolutionary tendency is more accentuated in the species *S. latastei* from Australia, which occurs without change in Chile, and which is also represented in Brazil by the form *tenuispina*. In Australia again, the species *S. maccullochi* Coutière differs most markedly from *S. paulsoni* *kurracheensis* by the presence of large eggs producing mysis.

There are found forms derived from *S. paulsoni* at the Mascarene Islands and on the west coast of Africa, of which I have been able to study very unusual specimens from Cape Lopez and from Cape Verde; these are not strictly typical specimens, but can be separated only by careful study, and it is impossible for me to make them distinct species, in spite of the great actual geographical isolation, which can probably be considered as absolute.

On the American coasts are found exactly the same evolutionary tendencies in this group; *S. paulsoni* and the other Indo-Pacific forms are not represented there by identical forms, but the differences are at times so slight that, without indication of locality, the identification would be very difficult. *S. lockingtoni* differs from *S. paulsoni* almost solely by the spine of the scaphocerite being longer in the latter and surpassing the carpocerite; with the exception of the place of origin, the second species would correspond to the "*oxyceros*" form so often met with that it appears to be almost a constant variation among the subspecies of a given species.<sup>a</sup>

<sup>a</sup> It is more convenient and expressive to designate by the name "*oxyceros*" every subspecies showing this variation, but in deference to the accepted rule of nomenclature which forbids duplication of names within a single genus, I have in this paper used different names having a similar meaning, as *longicornis*, *elongatus*, *productus*, *prolatus*, *extentus*.



This "*oxyceros*" form of *S. lockingtoni* exists, moreover, on the coast of Lower California. It is at present represented only by a single mutilated specimen collected by M. Diguët (Paris Museum), the characters of which I believe to have specific value, and which I designate by the name *S. paulsonioides*. Compared to *S. paulsoni*, instead of *S. lockingtoni*, it differs by its appendages and especially the third pair of feet, which are more slender. This comprises the known variations in this direction, the carpocerite remaining short, with the exception, of course, of *S. latastei* of Chile and its *tenuispina* form from Brazil just now cited.

The second evolutionary direction (the carpocerite remaining slender while becoming much elongate) does not appear to be represented on the American coast; on the other hand, the forms with carpocerite long and swollen are predominant. *S. apioceros* Coutière is found here, accompanied by at least four varietal forms coming from California, Florida, the West Indies, Venezuela, and Brazil; in regard to the last four forms, one can not say whether the geographical isolation is real, or whether it only appears so because the intermediate connectives are not known; but the isolation of the Californian form is absolute, and yet the differences which separate it from the specimens from Florida are quite as slight and difficult to detect as are those which separate these last from the other three forms which the species assumes. While it is possible that there may be as many species quite distinct and unrelated to one another, yet it is absolutely undeniable that the characters of these five forms are less distant than are those which separate *S. apioceros* from *S. paulsoni*. Nomenclature does not permit the expression of this, discarding (with good reason) every hypothesis conveying the idea of a possible affiliation between species—affiliation to which the idea of these "lesser species" directly leads.

Another species with carpocerite less swollen is *S. townsendi*, very widely distributed on both shores of America. It differs most of all from the preceding in the superior spine of the basicerite being almost or quite absent, so that these two species show a striking parallelism with *S. acanthitelsonis* and *S. hastilicrassus* Coutière of the Maldives. *S. apioceros* and *S. acanthitelsonis* especially differ only in the angles of the telson, which are very sharp in the second species. The divergence is but little greater between the two others.

Those species with basicerite unarmed above are important from another point of view, in that they permit of a passage to the NEOMERIS group by certain forms, such as *S. paraneomeris* Coutière. This species, very widely distributed from the Red Sea to the Hawaiian Islands, with several "races" (probably among them the "*oxyceros*" form), differs particularly from the American *S. townsendi* or from *S. hastilicrassus* of the Maldives by the dactyls of the

third, fourth, and fifth feet bearing a third and very obtuse ventral prominence. This prominence, very frequent in the *NEOMERIS* group, sometimes becomes a strong triangular hook, but a character still more often met with (with or without the last) is the reduction of the dorsal hook of the dactyl, the ventral hook taking the form and thickness of a wooden shoe, as in the curious species *S. charon* Heller. The Indo-Pacific region harbors a large number of species of this group, very easy to distinguish by reason of the characters in the striking form of the dactyls; among them those are especially curious in which exist—or reappear—the rows of spines of the meropodites, so constant in the primitive Eucyphota, and persisting in the Alpheidæ only on the propodite.

These forms of the *NEOMERIS* group with spinous meropodites appear to be totally absent from the American coasts. There also the parallelism with the Indo-Pacific forms is carried very far. Between *S. hemphilli* Coutière of Florida and *S. nilandensis* Coutière of the Maldives (both of which show an "*oxyceros*" form) there is no difference except the presence in the latter, and the absence in the former, of the meral spines; and yet, oddly enough, one quite full-grown specimen of *S. hemphilli*, from the Bermudas, shows on one side only a single meral spine. It is difficult to record such observations without thinking of a common origin for the two species, so completely separated at the present time, and yet so strictly parallel.

Another species, *S. fritzmuelleri* Coutière of Florida and the West Indies, exists also in Venezuela and Brazil, where it is represented by the "*oxyceros*" form; it is found again in California with the meropodites more slender. In Ecuador *S. nobilii* Coutière, a form in which the meropodites are, on the other hand, shorter and more swollen, replaces *S. fritzmuelleri*. In the Indo-Pacific region, *S. bakeri* Coutière, in which the supernumerary ventral prominence is very feeble, is the species most closely allied to the preceding ones.

Another very striking instance of parallelism is the existence in Lower California and in the Red Sea of the species *S. sanlucasi* Coutière and *S. heroni* Coutière respectively, both characterized by the very massive form of all the appendages. The modes of differentiation of the species are again repeated. A form being found, for example, with a short carpocerite, one may expect to meet those with a long carpocerite, then those with more slender members, with more massive members, with basicerite spinous above, or not, with large chela unarmed or spinous on the palmar border, those in which the angles of the telson are prolonged in a spine or not, etc. One can not avoid drawing the conclusion that such a constancy in the modes of variation strongly resembles an hereditary tendency, due to the small number of species from which the genus *Synalpheus* must have sprung.

The BREVICARPUS group is extremely like the PAULSONI group, and it is very possible that it may have been derived from the latter; the absence of an inferior vertical prolongation of the rostrum, the fact that all the species known have the carpocerite elongated, often swollen, indicate derivative and not primitive forms. On the other hand, it is there that are found the species having the largest antennal scale (*S. brevicarpus* Herrick), which is a character directly opposed to the preceding; but *S. brevicarpus* is a species with very large eggs producing mysis, a character which appears especially to show itself in those forms which are most highly developed. Finally, the BREVICARPUS group is, up to the present time, exclusively American. Should its presence be established in some part of the Indo-Pacific—in Australia, for instance—the American region would surely remain its true country. Compared to the preceding groups it has an unusual distribution, inasmuch as the species which compose it extend from the Bermudas to Brazil and from California to Ecuador, exactly like the American forms of the PAULSONI or NEOMERIS groups. These last appear to have had rather an Indo-Pacific origin, if one may judge by the number and variety of the forms which represent them in that region. One is led then to wonder if the origin of the BREVICARPUS group ought not to be sought for also in some of the species of the PAULSONI groups; this might have found only in American waters the conditions which have brought about its variations in the direction of the BREVICARPUS group.

Being given the form *brevicarpus*, the most typical species with small eggs is *S. minus* (Say), from which one is able to derive an "*oxyceros*" form from Brazil, an *antillensis* form with antennules short and carpocerite more swollen, and a form with antennules very long and slender, *S. digneti* Coutière from Lower California. A form of this species, *S. ecuadorensis*, exists upon the Pacific coast of South America. The species *S. brevicarpus* (Herrick) with very large eggs differs in its more slender carpocerite and larger antennal scale. It is the largest species of *Synalpheus* known. All these species are separated by slight differences. It is probable that *S. minus* (Say) comprises several "races" other than those indicated here and behaves as does *S. paulsoni* in the Indo-Pacific region.

The BIUNGICULATUS group includes among its species *S. neptunus* (Dana), the types of which I have been able to examine, and specimens of which have also been sent me from Australia by Mr. McCulloch. *S. laticeps* Coutière, of the Maldives, is very like it. These two species have the finger of the small chela widened and spatuliform, ornamented besides with some long hairs, which in *S. neptunus* are arranged in rows. These hairs are directed obliquely downward, and isolated, which is not the usual disposition in the



group. In *S. biunguiculatus* Stimpson, in the forms *pachymeris* Coutière, *lophodactylus* Coutière, and *pescadorensis* Coutière, these hairs are disposed in tufts formed in line, directed obliquely downward or even perpendicular to the surface of the mobile finger (*S. lophodactylus* Coutière); at the same time, the chela terminating the second pair is provided with a large number of tufts of long hairs, some carried by the palm, especially on its lower face, others by the movable finger, these last arranged regularly in a brush.

Judging by the sketch of an Australian specimen at the British Museum, taken some time previously, *S. spiniger* (Stimpson), with recurved hook, would also fall in this group, but this is not significant at the present time.

No American species, unless it be *S. spinifrons* (H. Milne Edwards), belongs to the BIUNGUICULATUS group; this species can be equally claimed by the LEVIMANUS group, this group, as I have pointed out, being the continuation, pure and simple, of the preceding one, the characters of which it extends to the extreme limit, especially those which concern the reduction of the antennal scale. The character which essentially distinguishes the two groups, in spite of its constancy and its importance, is itself only the variation in the cleansing apparatus present in the species of the BIUNGUICULATUS group; the bristles of the chela of the second pair, especially those of the movable finger, have not persisted in the LEVIMANUS group, while the brush of the little chela of the first pair has acquired the quite remarkable development that I have described above. If one tried to express these facts in plain language one would say that the experiment of the numerous cleansing appliances had been abandoned in the descendants of certain of these species, and that a single apparatus, much more perfect, had been substituted for them.

The continuity of the two groups is so evident that it leads to this conclusion: If the species of the BIUNGUICULATUS group are not represented on the American coasts, it is because they have all undergone the variation toward the LEVIMANUS group, with the exception, perhaps, of *S. paraneptunus* Coutière, a species particularly instructive because of the much more feeble development of the brush of bristles of the small claw.

In the Indo-Pacific region, on the other hand, this variation appears to be very rarely realized, since the only species which presents it up to the present time is *S. sladeni* Coutière, which has not, however, altogether the aspect of the American species of the LEVIMANUS group.

A rather similar condition is observed in the relations between the PAULSONI and BREVICARPUS groups, with two differences: First, the species of these two groups are still found side by side on both American coasts; second, the known distribution of the LEVIMANUS



group is at present much less restricted than that of the *BREVICARPUS* group, since it is known in the Indian Ocean, on the west coast of Africa, and in the Mediterranean. If the idea of time could be introduced into these data, one would say that the differentiation of the *BREVICARPUS* group is more recent; thus would also be explained its presence exclusively in America as well as its coexistence with the *PAULSONI* group, from which it has come, and its relatively small number of species. All these characters are opposed to the much wider distribution of the *LEVIMANUS* group, to the localization of the derived species of the *BIUNGUICULATUS* group and to the excessive development of the forms which characterize the *LEVIMANUS* group.

The armature of bristles of the small claw gives to these forms a common aspect so characteristic that it can hardly be believed, in a superficial examination, that there is room for so great a number of species within a compass of differences apparently so slight. It is, however, probably true even further than I have indicated, that several of the races or subspecies have a specific value. On the whole, one may say that the species of this group tend toward the elongation of the wrist of the small claw and the suppression of the antennal scale. These two tendencies are met with occasionally within the same form, such as *S. longicarpus*, in which the length of the wrist varies from once to twice the width with the age of the specimens. But there are grafted onto this general plan some characters quite unexpected, such as the curious form of the fingers of the small claw in *S. pectiniger*, the excavated meropodites of *S. androsi*, and the basicerite with a longitudinally spinous superior surface, of *S. rathbunae*. No other group gives the impression as does this one of having sprung from a single species, by "explosion" of its characters (to employ the expression of Standfuss), characters which might be regrouped by chance like a combination of letters.

Remarkable from a morphological point of view, the *LEVIMANUS* group is no less remarkable as to conditions of existence. It is the only one in which a single haul of the dredge of the U. S. Fisheries steamer *Albatross* (Station 2413) has been able to bring up from 5,000 to 3,000 specimens (belonging to the two species, *S. longicarpus* (Herrick) and *S. pectiniger* Coutière). It is this group in which anomalies in the laying of eggs are met with most frequently; among 227 females of *S. pectiniger* (Station 2413), of which I have determined the sex by examining them singly with the greatest care, I have been able to find only two or three in which the pleura were normal and the eggs present, and have been able to find none with the very large eggs carried by the normal females. The males which accompany them are 320 in number, with some closely united, all inferior in size to the normal. I propose to conduct investigations

to determine whether the castration so general among these females is due to a parasite, Microsporidian or Bacterian, or simply to hunger. Neither do the *S. longicarpus* which accompany them possess their maximum size; the males are largely in excess, but the eggs of the female are altogether normal.

One frequently finds some anomalies of the same sort in *S. brooksi* Contière, in which the eggs give rise also to mysis as in *S. pectiniger*. The eggs may be reduced to two or three; they are then very small and of a chalky aspect, and at the same time the size of the female is very much reduced. *S. rathbunæ* is known to me up to the present time only by some sterile females, very small, in which the pleura are extremely spinous as in the male.

These species appear, then, to be sometimes found in very precarious conditions, from the point of view of their perpetuation, and the study of these conditions would probably be most interesting; their abundance in the collections accords well with what Herrick says when he speaks of the constant fusillade which one hears on the reefs of the Bahamas from the movements of the Alpheids, and it seems to me that they would lend themselves to constant observation in an aquarium in such a manner as to make possible some "pure cultures" of a determined species.

After an examination of the facts, it is difficult to avoid the temptation to draw from them some hypothetical conclusions. When one investigates the distribution of the Synalpheids known at the present time, the most striking fact is the existence of forms almost identical in regions so remote as the Red Sea and California or Florida. Now, these are very sedentary animals, which are almost never seen to swim, but live in couples in sponges or madrepores; their larvæ, to be sure, could be disseminated by the currents, but the possible extent of that dissemination should not be overestimated, and when two species are separated by both the Pacific and the Indian oceans, they are certainly isolated in the most rigorous fashion. I can not repeat too often that the Indian *S. paulsoni* and the Californian *S. paulsonoides*, *S. mushacnis* and *S. lockingtoni*, *S. acanthitelsonis* and *S. apioceros*, *S. nilandensis* and *S. hemphilli*, etc., might very well, without indication of locality, be considered as simply "races," and there is the inevitable inference that former conditions under which the antecedent species lived permitted a very vast distribution. Nothing shows that these species still exist, but at all events they have changed, since the forms which represent them in different localities are no longer exactly comparable. There is, as an exception, only the single species *S. latastei*, the specimens of which from Chile I can not differentiate from another—a single one, it is true—from Australia. This exception, when critically examined, only goes to strengthen

very much the idea of species primitively widely dispersed; perhaps it will even render less uncertain the position of the continuous line of coast along which the dispersion might have been made. It seems to me that one might sketch this original distribution under the form of a few waves of very great amplitude, on which, at variable points, might have originated new systems of waves of the second order, of less amplitude. *S. paulsoni* at one extremity, *S. paulsonoides* at the other, would represent such systems, turning aside more or less from the wave of the first order, to continue the comparison, being able even to substitute themselves for it and to efface it. On these would be produced, by the same hypothetical mechanism, waves of the third order, of still shorter amplitude, as, for examples, the races or subspecies with trinomial appellations which are attached so obviously and so closely to *S. apioceros*, to *S. townsendi*, to *S. minus*, and to *S. herricki*. The comparison permits us even to imagine that the characters served at first to distinguish species, and that as the waves spread and multiplied they changed their original valuation and became characters of groups, and even generic characters.

In order to complete the hypothesis, one might speak of the "pebble" which, falling on the summit of a wave of great amplitude, might have given rise to a new system of vibrations, otherwise called a new form. If one seeks to represent the one or the other of the two possible mechanisms, insensible "fluctuations" or sudden "mutations," one encounters the same impossibility of knowing. It is easy to see at a glance that the two modes do not exclude each other, that they are even very near to overlapping, provided we admit an amplitude small enough for effectual variations. There are perhaps some zoological groups which behave in a different manner from this point of view. Each molt of an arthropod is a "mutation," while a vertebrate "fluctuates" in order to attain its adult characters. According to Professor Bouvier, who has in such a masterly manner demonstrated the reality of mutations among the Atyidæ and their great amplitude, it would not be surprising if one found among other Crustacea analogous examples.

I think I can say that the Synalpheids at the present time show nothing similar. I have examined, drawn, and measured all the specimens of which I speak, excepting in the cases where the species comprised several hundreds or more than a thousand specimens, which for want of time I have only examined. The details which can be referred to the facts of mutation by their unusual presence in a series of specimens appear to be very few in number and without special importance. For example, first, one of the specimens of *S. apioceros sanjosei* has no spine on the anterior border of the wrist, which fact permits of no hesitation in its determination; second, one



of the specimens of *S. hemphilli longicornis* bears a movable spine on one of the meropodites of the third pair; it is the reappearance, very interesting, of a character present in many of the NEOMERIS species (Indo-Pacific), which seems to have disappeared in the American species, even those most like the preceding. It is not a "mutation" permitting one to understand the process by which a new form is originated; third, a specimen of *S. minus* possesses on the anterior border of the palm of the small chela a spinous tubercle as on the opposing chela: this is a "mutation" which is not absolutely rare in the Alpheidae, and which I have seen even carried so far as to result in the complete symmetry of the two claws of the first pair in a very curious specimen of *Alpheus dentipes* Guérin. But the Alpheidae have originated from forms with symmetrical claws; there, again, it is the question of the recurrence of a remote character, and not the indication of a new evolutionary line; fourth, some specimens of very small size of *S. longicarpus*, and of *S. brooksi* also, have only four segments in the carpus of the second pair; this detail characterizes the species *S. rathbunae*, which is far from being the nearest to *S. brooksi*, but it characterizes also the genus *Arctc*, the relations of which with the genus *Synalpheus* are truly very remote.

Concurrent with these facts, obvious, but without importance, may be cited other facts of greater weight but without proofs. The characters of the subspecies *S. brooksi strepsiceros*, *S. herricki dimidiatus*, *S. herricki angustipes*, and of *S. tanneri*, occurring either among a series of typical specimens or in some localities where the typical specimens also occur, make one think of some "mutations;" it is, in fact, as I have said before, the case in the entire LEVIMANUS group; close relationship, a general resemblance of the forms which make part of it, but a great variety of combinations of a small number of characters, of which one at least is absolutely constant, certain combinations rarely realized, while others are frequent—even taking into account certain errors in the appreciation of the scarcity or the frequency of the type—a distinct aspect and clear-cut, though slight, differences. These are mere impressions without proofs, but which, I believe, would occur to every naturalist who has been able to study in its entirety so homogeneous a group; and it would certainly be interesting to attempt for a few of the species of the LEVIMANUS group some "pure cultures," continued during several generations, supposing that one might surmount certain considerable difficulties involved in such an attempt.

This work, in which the greater part of the forms described are new, necessarily allows of very few bibliographical references; those pertaining to the species of Say, Herrick, and Lockington, the names of which I have been able to retain, are given with the descriptions



of these species; for all the others, I refer to my work on the Alpheidae in general,<sup>a</sup> and to the paper on the Alpheidae of the Maldives.<sup>b</sup>

### DESCRIPTIONS OF SPECIES.

#### PAULSONI Group.

##### SYNALPHEUS LOCKINGTONI, new name.

*Alpheus leviusculus* LOCKINGTON, Ann. and Mag. Nat. Hist., 1878, p. 478;  
not *Alpheus edwardsi* var. *leviusculus* Dana, 1852.

I believe that I have rediscovered the species described by Lockington, although the specimens which represent it differ in slight details from his description.

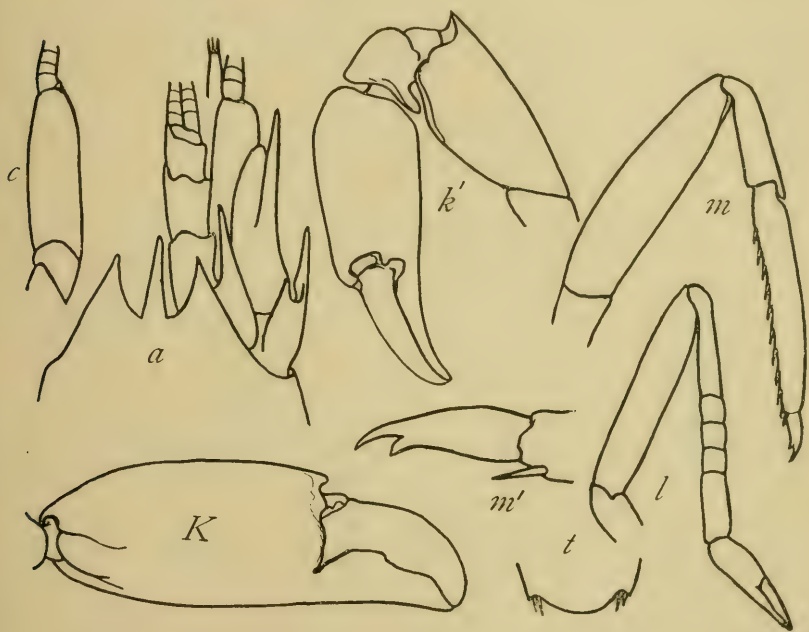


FIG. 1.—SYNALPHEUS LOCKINGTONI. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON.

The rostrum is a little longer than the lateral spines; it reaches the extremity of the basal antennular article, from which it is separated by notches which are narrow, but not sharp, at the base.

The last two antennular articles are practically equal, the antennule being 4.4 times as long as wide; the basal article is only 1.5

<sup>a</sup> Annales des Sciences Naturelles (8), IX, 1899, pp. 1-56.

<sup>b</sup> The Fauna and Geography of the Maldivé and Laccadive Archipelagoes, II, Pt. 4, 1905, pp. 852-920.

longer than the median; the stylocerite usually reaches the distal third of the median antennular article, but always to at least the middle of the article.

The lateral spine of the basicerite is as long as the rostrum; the lateral spine of the scaphocerite is very slightly shorter than the carpocerite, which is short, beginning at the distal third of the basal antennular article, three times as long as wide, the margins almost parallel, excepting at the base, where it is slightly swollen; it exceeds the antennule by one-half the length of the distal article; the outer maxillipeds exceed the antennule by about one-half of its length.

The anterior margin of the palm of the large chela terminates in a conical tubercle, short and always destitute of a spine, as Lockington distinctly says. I found the proportions of the chela to be: Finger 1; total length 3; height 1.1; proportion T. L.:H.=2.9:1. The anterior margin of the meropodite terminates in a triangular point.

The proportions of the small chela are: Fingers 1; total length 2.36; height 0.84; proportion T. L.:H.=2.8:1. The carpus is not spinous on its superior margin; the meropodite terminates on this margin in a triangular point, its thickness being a little less than that of the palm, contained 1.9 times in its length.

In the second pair the first segment of the carpus is slightly shorter than the sum of the four following ones; the meropodite is shorter than the carpus.

The meropodite of the third pair is approximately equal to the carpus of the second pair, and 3.75 times longer than wide. The proportions of the members are: Carpus 1; propodite 2; meropodite 2.15; the dactyl is very slender, the dorsal hook twice as long as the ventral.

The posterior angles of the telson are right angles, not prolonged to a triangular prominence.

Named for Mr. W. N. Lockington, the original describer of the species.

The description by Lockington—very explicit as to the length of the antennal spines, the form of the chela of the first pair, the carpus of the second pair, the dactyl of the third pair, and the telson—appears to permit identification of the specimens of *S. leviusculus* with those which I have studied. The differences bear upon two points: Lockington says that the spine of the scaphocerite does not reach the extremity of the peduncle and that the movable finger of the large chela projects beyond the pollex. The first character hardly exists on the specimens that I have seen, the spine being approximately equal to the carpocerite and the fingers of the large chela equal.

Lockington's specimens came from Port Escondido, Port Mulege, and other points in the Gulf of California. Those which I have studied were collected by the steamer *Albatross*, of the U. S. Bureau of Fisheries, on the California coast at Station 4421, eastern point San Nicolas Island N.  $26^{\circ}$  W. 3.8 miles, 229–298 fathoms.

This species is particularly important because of its resemblance to *S. paulsoni* Nobili from the Red Sea and the Persian Gulf. There is but one difference between the two species: The spine of the scaphocerite in *S. paulsoni* always exceeds the carpocerite. If, however, one were studying the two species without a knowledge of their source, one would be led to make of the *S. paulsoni* an "*oxyceros*" form of *S. lockingtoni*.

*S. paulsoni*, in the group which bears its name, is a form with short carpocerite, that article arising a little below the extremity of the

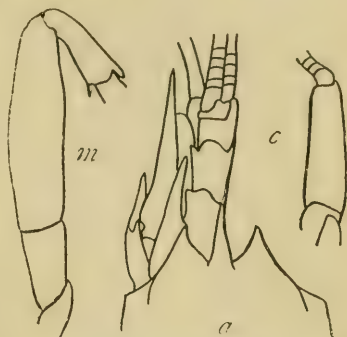


FIG. 2.—SYNALPHEUS PAULSONI. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *m*, PORTION OF THIRD FOOT.

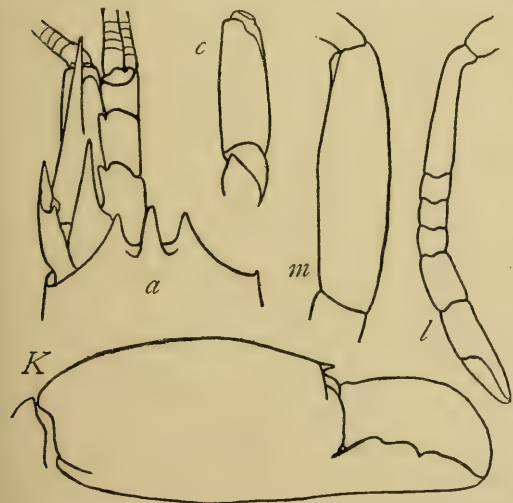


FIG. 3.—SYNALPHEUS PAULSONI KURRACHEENSIS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *l*, FOOT OF SECOND PAIR; *m*, MEROPODITE OF THIRD PAIR.

basal article of the antennule. It is a character which seems to me to be very essential for the diagnosis of the species of the group, the carpocerite being elongated and slender or elongated and thick, and also important because the forms with short carpocerite may be considered as less developed, as that article is always short in the primitive Eucyphota.

In the Indo-Pacific region, *S. paulsoni* is surrounded by a certain

number of derived forms: *S. paulsoni liminaris* Coutière, in which the carpocerite is a little longer and the basicerite almost unarmed above; *S. paulsoni rameswarensis* Coutière, in which the interior palmar border is spinous; and *S. paulsoni kurracheensis* of a more massive general form, very interesting, in that it indicates the direction

in which the species *S. latastei*, of Australia and Chile, is differentiated. I have believed it possible to separate as a distinct species *S. hululensis* Coutière from the Maldives, which I have described in my work on the Alpheidae of that archipelago under the name of *S. tumidomanus* Paulson; but *S. tumidomanus* is very distinct from it, as shown by the angles of the telson being clearly spinous (as Paulson has figured it), and also by the very large eggs which give rise to mysis. In these last two forms the carpocerite has become distinctly elongate and slender (at least four times as long as wide).



FIG. 4.—SYNALPHEUS HULULENSIS. a, FRONTAL AND ANTENNAL REGION; c, CARPOCERITE; t, TELSON.

I have also separated from *S. paulsoni*, under the name of *S. mushaensis* Coutière, a specimen from the Red Sea, received from M. Gravier, in which the antennal scale is notably shorter than the antennule and still shorter than the carpocerite. This species is again extremely like *S. lockingtoni* from California and Lower California.

Although the forms with a short carpocerite are at present less numerous on the Californian coast than those with a long one, the parallelism between them and those of the Indo-Pacific is again accentuated by the following species which I believe should be separated from *S. lockingtoni*.

**SYNALPHEUS PAULSONOIDES, new species.**

The species differs from *S. lockingtoni* by the following points:

The antennal scale equals the antennule, and the lateral spine of the scaphocerite considerably exceeds the carpocerite, which is four times as long as wide. The carpus of the small cheliped has its anterior border prolonged in a spinous prominence. The feet of the third pair are very slender. Their proportions are: Carpus 1; propodite 2; meropodite 2.35; this last being 5.3 times as long as wide.

The specimen, a male, is unique and its large cheliped is wanting; but it is very easily distinguished from *S. lockingtoni*, especially by the slenderness of the meropodites of the third pair. It corresponds, as the Indo-Arabic *S. paulsoni*, to an "*orycceros*" form of the species



FIG. 5.—SYNALPHEUS TUMIDOMANUS. a, FRONTAL AND ANTENNAL REGION; c, CARPOCERITE; t, TELSON.



previously cited, but in a different direction. Up to the present time, in fact, I know of no form which is exactly the same in both regions.

*S. paulsonoides* is from the island of San José, Lower California (M. Diguët, Paris Museum).

On the South American coasts the species with short carpocerite of the PAULSONI group are similarly represented. The species *S. latastei* Coutière, described below, is of great interest. It possesses in Brazil a "*tenuispina*" form which is with difficulty separable from some specimens from Cape Lopez, in West Africa. On the other hand, it exists in Australia, for I can not differentiate from the typical Chilean specimens the unique Australian individual which I have examined. In Australia, moreover, a species with very large eggs, *S. maccullochi*, is shown to be closely allied, and *S. paulsoni kur-racheensis*, previously cited, clearly resembles it also, though its appendages are a little more massive.

SYNALPHEUS LATASTEI, new species.

The rostrum is longer than the frontal spines, and also wider; the antennular articles are short and approximately equal; the proportion of the antennule is only 1:3.85, the diminution in length affecting especially the basal article; the stylocerite is shorter than in *S. lockingtoni*; the lateral spine of the basicerite is as long as the stylocerite; its superior spine is short and strong.

The antennal scale, rather reduced, is 5.7 times as long as wide, and its long and strong lateral spine exceeds the antennule by the length of the distal article, and usually slightly exceeds the carpocerite, which arises from the same level as the median antennular article; the proportion of its dimensions is 1:2.71, sometimes even 2.66; its form is more cylindrical than in *S. lockingtoni*.

The large chela, which recalls the preceding species by the absence of any spinous prominence on the anterior margin of the palm, differs from it by its more stocky form: Fingers 1; total length 3.4; height 1.5. The small chela has the same proportions as in *S. lockingtoni*; the meropodites of the two chelipeds terminate on the superior margin in a spinous prominence.

In the second pair, the first article of the carpus, the four following and the chela are to one another as 1.2, 1.25, 1. The proportions of the third pair are: Meropodite 2; carpus 1; propodite 1.6; the meropodite is 3.12 times longer than wide, and consequently very stout.



FIG. 6.—SYNALPHEUS PAULSONOIDES. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *m*, MEROPODITE OF THIRD FOOT.

The telson has the same form as in *S. lockingtoni*. This species seems to be frequent in Chile, from which locality I have been able to examine some ten specimens, thanks to M. Lataste, of the Paris Museum, after whom the species is named; the species is also met with in Australia (?) (one male of great length without indication of locality other than New Holland; Paris Museum).

The size is greater than in *S. lockingtoni*. It reaches 30.5 mm. in length from the rostrum to the telson.

I have been obliged to separate from the typical species, under the name *S. latastei tenuispina*, a large female from Desterro which dif-

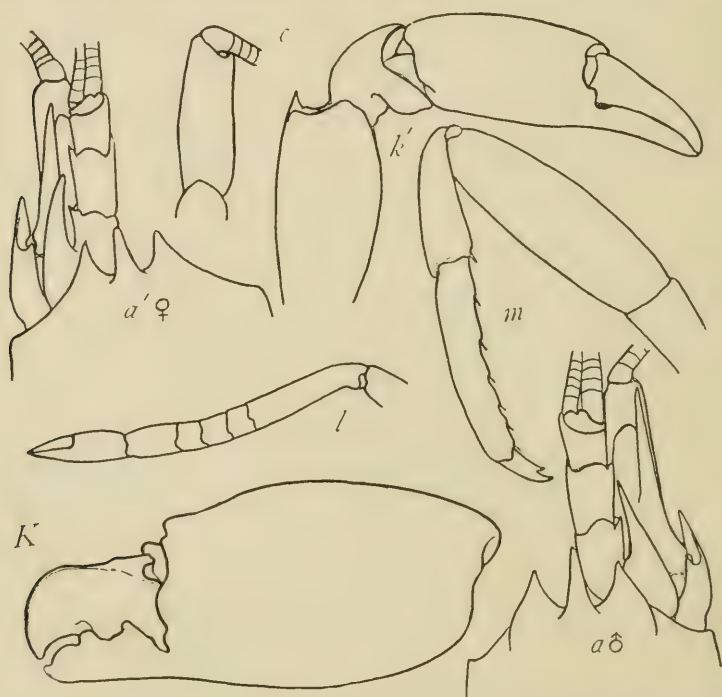


FIG. 7.—SYNALPHEUS LATASTEI. *a*, FRONTAL AND ANTENNAL REGION, MALE, AUSTRALIA; *a'*, FRONTAL AND ANTENNAL REGION, FEMALE, CHILE; *c*, CARPOCERITE; *K*, LARGE CHELA; *K'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR.

fers from it in the following points: The antennule is less thick (four times as long as wide instead of 3.85); the scale of the scaphocerite equals the antennule, and its very sharp lateral spine exceeds the carpocerite very considerably, the latter being 3 times, or even 3.04 times, longer than wide. The meropodite of the third pair is 3.3 times as long as wide, instead of 3.1 times, as in *S. latastei*.

This form approaches closely to *S. lockingtoni* from California and Lower California, differing from it, however, by the large and more massive chela (proportions T. L.: H. = 2.5:1 instead of 2.9:1), the

fingers of which are shorter (fingers 1, height 1.4, instead of 1.1). The feet of the third pair are also more massive (meropodite 3.3 times as long as wide instead of 3.74), and the feet of the second pair, as in *S. latastei*, have the distal chela feeble and the first segment of the carpus equal in length to the four following ones.

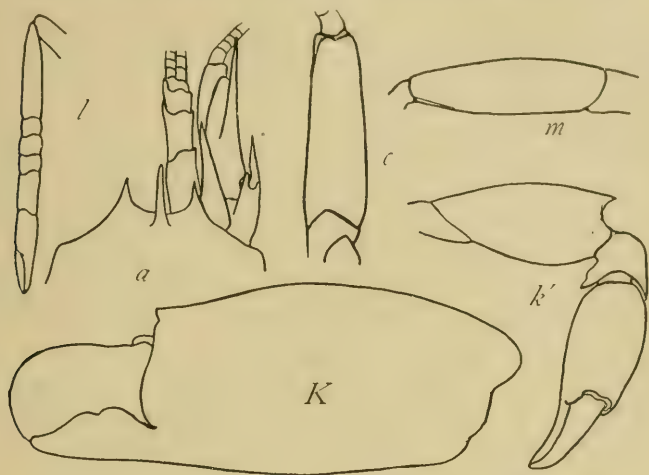


FIG. 8.—SYNALPHEUS LATASTEI TENUISPINA. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPO-CERITE; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, MEROPODITE OF THIRD PAIR.

Desterro, Brazil; Fritz Müller; one female 30 mm. long (Paris Museum).

SYNALPHEUS APIOCEROS, new species.

On the Atlantic coast of America the PAULSONI group is represented by additional species; one of them, *S. townsendi*, described farther on, is, up to the present time, the most aberrant form of the group known; it possesses no spine in the superior angle of the basicerite, and thus closely resembles *S. paraneomeris* of the NEOMERIS group; this resemblance is further accentuated by the fact that the dactyls of the third, fourth, and fifth pairs in the preceding species possess only a trace of triunguiculation. Thus these two species mark the varietal limits of the two groups of forms.

The other species, *S. apioceros*, also new, is, on the other hand, very typical. It is of special interest because of the great number of allied forms, American or Indo-Arabic, which may be approximated to it.

The rostrum is equal to the lateral teeth, from which it is separated by intervals acute at base; the antennule is about 4.6 times as long as wide, but its basal article is 2.2 times as long as the median, and considerably exceeds the frontal teeth. This is a character which distinguishes this species at once from *S. lockingtoni*.

The stylocerite scarcely reaches the middle of the median article; the superior spine of the basicerite nearly equals the frontal teeth; its lateral spine does not reach the extremity of the basal antennular article; the scale of the scaphocerite, five times as long as wide, is shorter than the antennule, its lateral spine slightly shorter than the carpocerite, which last, three times as long as wide, is swollen at the base and pyriform; it is long in the sense that it takes its origin below the point where the stylocerite is detached from the basal article of the antennule and that it exceeds the antennule by about two-thirds of its distal article.

The outer maxillipeds do not exceed the carpocerite. The large chela has the following proportions: Fingers 1; total length 3.15;

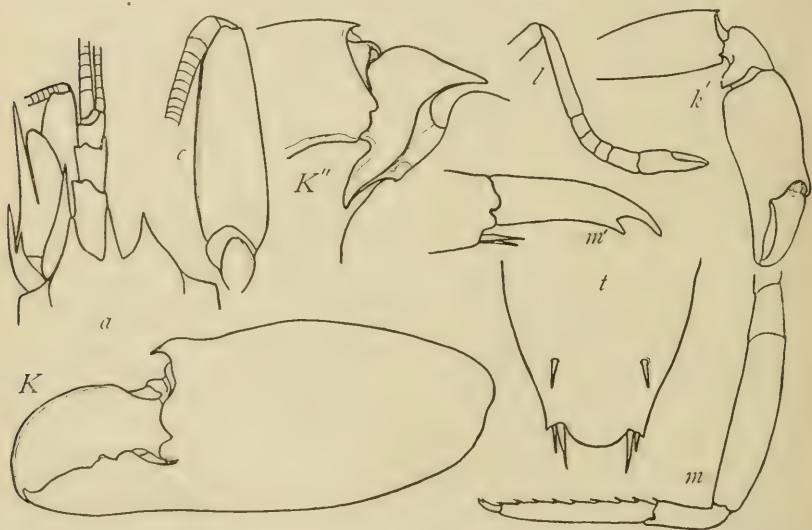


FIG. 9.—SYNALPHEUS APIOCEROS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *K''*, CARPUS OF LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON.

height about 1.28; the proportion T. L.: H.=2.8:1; the anterior border of the palm is swollen in a tubercle, which terminates in a spine directed slightly obliquely downward.

The small chela has, as proportions, fingers 1; total length 2.8; height 0.95; T. L.: H.=2.95:1; it is thus relatively slender with short fingers; the wrist is spinous on its supero-external border; the meropodite, a little less thick than the palm, is 2.35 times longer than wide. The proportion of the two chelæ is about 1:3.

In the second pair the first segment of the carpus equals apparently the sum of the others, and the meropodite is more slender than in *S. lockingtoni*; the chela is also notably shorter.

The proportions of the third pair are: Carpus 1; propodite 2; meropodite 2.28, this last being a little more than four times as long as



wide. The dactyl is slender, about 3.2 times as long as wide, with the ventral hook relatively shorter than in *S. lockingtoni*.

The telson has its posterior angles accented, but not spinous. The eggs give rise to zoëa larvæ.

#### Localities:

Jamaica, *Albatross*.

Marco, Florida, 1 to 3 fathoms, H. Hemphill (Cat. No. 7000).

Marco, Florida, in sponges, H. Hemphill (Cat. No. 6970), type.

The species differs, then, from *S. lockingtoni* in many ways; the rostrum and stylocerite are shorter, the basal article of the antennule is longer, the carpocerite of different form and proportions, the maxillipeds shorter, the large chela is spinous on the palmar border, the small cheliped is more slender, its carpus spinous and the second and third pairs are more slender.

One is induced to separate from *S. apioceros* a whole series of forms of different geographic origin, probably constituting as many distinct species. They differ, nevertheless, very little from typical specimens and correspond well to what are called "petites espèces."

#### SYNALPHEUS APIOCEROS SANJOSEI, new subspecies.

This subspecies is represented only in the collection of the Museum at Paris by some specimens (male and female) collected by M. Diguët. It is from San José Island, Lower California, and is as distinct from *S. lockingtoni* of California as is the preceding, from which it differs in the following details:

The rostrum is usually a little longer than the lateral spines; the stylocerite scarcely surpasses the basal article of the antennule; the lateral spine of the scaphocerite is notably shorter than the carpocerite; the carpus of the small cheliped is unarmed above. The small chela has these proportions: Fingers 1; total length 2.56; height 1.1; T. L. : H. = 2.34 : 1; it is thus more massive than in *S. apioceros*, where the last proportion is 2.95 : 1.

The meropodite of the third pair is 3.56 times as long as wide.

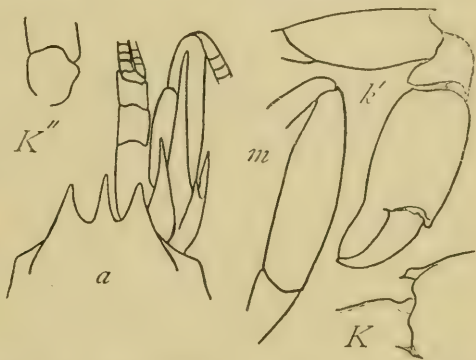


FIG. 10.—SYNALPHEUS APIOCEROS SANJOSEI. *a*, FRONTAL AND ANTENNAL REGION; *K*, SPINE OF LARGE CHELA; *K''*, CARPUS OF LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR; *m*, MEROPODITE OF THIRD PAIR.

## SYNALPHEUS APIOCEROS MAYAGUENSIS, new subspecies.

I have examined four specimens from Porto Rico belonging to this form. They are not, however, strictly alike. The most typical among them differ from *S. apioceros* in the following particulars:

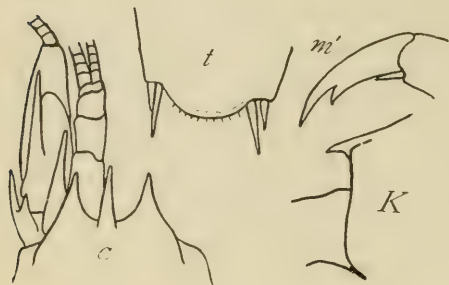


FIG. 11.—SYNALPHEUS APIOCEROS MAYAGUENSIS. *a*, FRONTAL AND ANTENNAL REGION; *K*, SPINE OF LARGE CHELA; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON.

Rostrum a little longer than the lateral spines; stylocerite attaining at least the middle of the median article of the antennule; scale of the scaphocerite only four times as long as wide; carpopocerite surpassing the antennule by  $1\frac{1}{2}$  times the length of the distal article, longer than the spine of the scaphocerite, and very swollen at base (only 2.8 to 2.9 times as long as wide); the spine of the large chela continues in a straight line the anterior margin of the palm, which presents no swollen tubercle; the dactyl of the third pair is 3.8 times as long as wide and its ventral hook is more feeble than in *S. apioceros*; the posterior angles of the telson are right angles.

The other specimens are distinguished from the preceding by slight differences in the width of the antennal scale, in the more slender feet of the second and third pairs, and by the more marked posterior angles of the telson. It is probable that more abundant material would permit of separating them also from *S. apioceros*.

*Type*.—Cat. No. 24785, U.S.N.M. Mayaguez, on coral reef.

## SYNALPHEUS APIOCEROS LEIOPES, new subspecies.

Some females collected by M. Chaper (Paris Museum) differ from *S. apioceros* in the following points:

The lateral spine of the scaphocerite always slightly exceeds the carpopocerite; the feet of the third pair are more slender, the meropodites being 4.4 times longer than wide; the telson has its posterior angles right angles.

Venezuela, precise locality unknown. Type in Paris Museum.

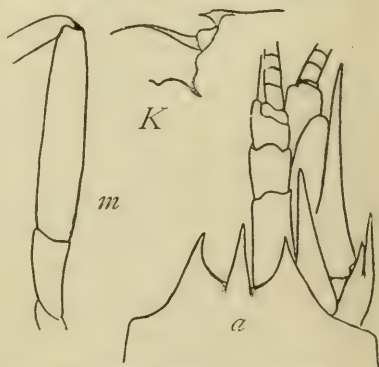


FIG. 12.—SYNALPHEUS APIOCEROS LEIOPES. *a*, FRONTAL AND ANTENNAL REGION; *K*, SPINE OF LARGE CHELA; *m*, PORTION OF THIRD FOOT.

## SYNALPHEUS APIOCEROS DESTERROENSIS, new subspecies.

This form is more distinctly separated from *S. apioceros* than the preceding; it is also more abundantly represented. The specimens (4 males, 3 females) come from Desterro (Fritz Müller; Paris Museum).

The rostrum is separated from the lateral spines by wide intervals with sinuous base; the basal article of the antennule is only twice as long as the median article, and the antennule scarcely four times as long as wide; the scale of the scaphocerite is from 4.1 to 4.3 times as long as wide, at least equal to the antennule, or longer; the lateral spine of the scaphocerite surpasses it very little, being shorter itself than the carpocerite; the maxilliped exceeds the antennule, and slightly the carpocerite; the spine of the large chela continues the anterior palmar border; the feet of the third pair are very slender, the meropodite being about 4.7 times as long as wide; the posterior angles of the telson are right angles.

All these forms, like *S. apioceros*, have zoëa larvæ. None possess large eggs. They themselves present slight individual variations when

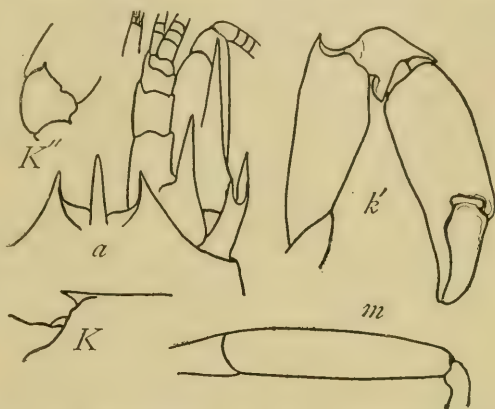


FIG. 13.—SYNALPHEUS APIOCEROS DESTERROENSIS. *a*, FRONTAL AND ANTENNAL REGION; *K*, SPINE OF LARGE CHELA; *K''*, CARPUS OF LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR; *m*, MEROPODITE OF THIRD PAIR.

the specimens representing them are numerous, and it is probable that they will be isolated hereafter as distinct species. I have noticed in one of the specimens of *sanjosei* the absence of the spine on the anterior border of the carpus. This is an example of a type of "mutation" with which one frequently meets in the Synalpheids, and which is of very slight importance.

In the Indo-Pacific region the forms with long and slender carpocerite, analogous to the preceding, have as the type *S. acanthitelsonis* Coutière, which differs from them almost solely by the very spinous angles of the telson, and *S. hastilivassus* Coutière, in which the superior angle of the basicerite is unarmed, and which consequently is closely allied to the species described hereafter.



## SYNALPHEUS TOWNSENDI, new species.

The rostrum is  $1\frac{1}{2}$  times as long as the lateral teeth, reaching usually to the end of the proximal third of the median article of the

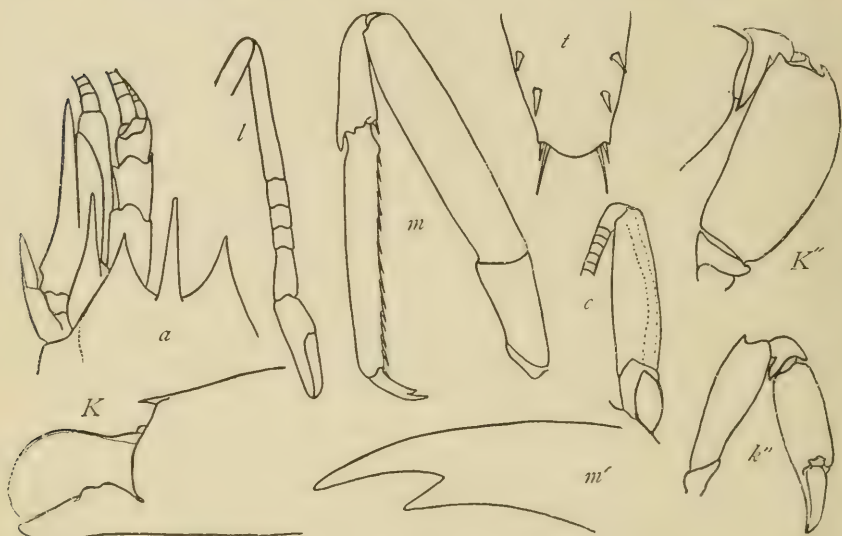


FIG. 14.—SYNALPHEUS TOWNSENDI. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *K''*, CARPUS AND MEROPODITE OF LARGE CHELIPED; *k''*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON.

antennule. On some specimens the frontal teeth are longer and more slender. The relative proportions of the articles of the antennule are: 2, 1.3, 1. The stylocerite reaches almost the middle of the median article.



FIG. 15.—SYNALPHEUS TOWNSENDI PRODUCTUS. *a*, FRONTAL AND ANTENNAL REGION.

The basicerite bears no spine above, where it terminates in an obtuse angle; its lateral spine reaches to the distal third, sometimes even to the extremity of the basal antennular article; the antennal scale is 5.6 times longer than wide; its lateral spine is long and reaches beyond the extremity of the carpopodite, which is scarcely longer than the antennule, and is 3.5 times as long as wide.

The large chela has the following relative dimensions: Fingers 1; total length 3.65 to 3.7; height 1.25; the anterior border of the palm bears a sharp spine; the carpus is very small, in the form of a coin; the supero-external margin of the meropodite (which is twice as long as wide) is very convex, terminated by a hooked spine.

The small chela is one-third as long as the large one; its relative dimensions are: Fingers 1; total length 2.5; height 0.8 or a little less. The meropodite is 3.1 times longer than wide; its upper margin ending in a sharp angle.

In the second pair, which is slender and elongate, the first article of the carpus measures 1, the sum of the four following is 0.83, and the chela 0.75.

The relative dimensions of the third pair are: Meropodite 2.41 (five times longer than wide); carpus 1; propodite about 2.14, the foot as a whole being long and slender, especially the propodite; the dactyl is also elongate, its ventral hook less thick and especially much shorter (about one-third) than the dorsal, with which it is parallel in direction.

The telson has sharp posterior angles, with the inner pair of spines very slender, three times longer than the outer pair; the convex posterior border has twelve plumose hairs.



FIG. 16.—SYNALPHEUS TOWNSENDI BREVISPINIS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHÉLA; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON.

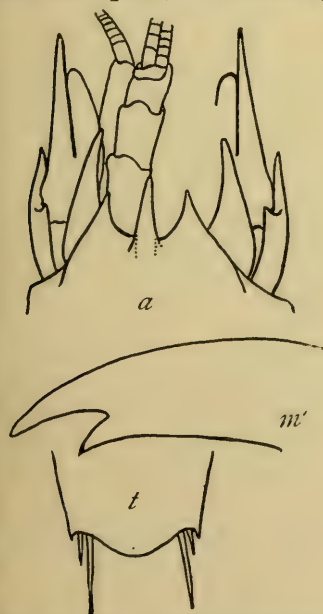


FIG. 17.—SYNALPHEUS TOWNSENDI MEXICANUS. *a*, FRONTAL AND ANTENNAL REGION; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON.

The eggs should give, in accordance with their size, zoëa larvæ.

This species represents on the American coasts *S. hastilicrassus* of the Laccadives and Maldives. The latter is distinguished by the large cheliped, in which neither the palm nor the meropodite is spinous, by the shorter dactyls of the thoracic feet, in which the ventral hook is the more important, by the telson having more pronounced angles, and the inner spines shorter than in *S. townsendi*. The carpopodite is also more swollen than in the last-named species.

*S. townsendi* shows some interesting variations. In a male specimen from Albatross Station No. 2406 (form *productus*) the rostrum and the frontal spines are very elongate, as is also the lateral spine of the scaphocerite. This "oxyceros" form (very frequent in *Synalpheus*), is seen likewise in the Maldivian species, *S. hastilicrassus*, at least as to the elongation of the rostrum.

This species is chiefly Atlantic, being known from the Bermudas, from Florida, the Bahamas, Cuba, and Porto Rico. It extends as far as Brazil, and, strange as it may seem, the *Albatross* collected it at the Hawaiian Islands at Station No. 3969. The species is met with, however, on the Pacific coast of America, represented by some specimens collected by M. Diguët (Paris Museum), which differ from those just described by the large chela, which has the palm obtuse, and the telson, in which the posterior angles are altogether right angles and the inner spines are shorter (form *brevispinis*).

Other specimens from the same region, collected by the *Albatross* (form *mexicanus*) have the basicerite slightly acute on the upper border; the frontal projections are short, the rostrum shorter than the basal article of the antennule; the ventral hook of the dactyls is a little larger, and the posterior angles of the telson are sharper than in typical specimens. These are very interesting differences, because they are the same which serve to separate the two species of the Maldives, *S. hastilicrassus* and *S. acanthitelsonis*, but here the characters of the basicerite and of the telson are much more marked.

Named for Mr. Charles Haskins Townsend, formerly naturalist of the *Albatross*.

#### Localities:

North Carolina, 15 to 16 fathoms, *Albatross* Station Nos. 2280 and 2619.

Florida: Key West (Union University collection); Anclote; Straits of Florida, 56 fathoms, *Albatross* Station No. 2640; west coast, 12.5 to 28 fathoms, *Grampus* Stations Nos. 5094 and 5100 and *Fish Hawk* Stations Nos. 7106, 7123 and 7124.

Gulf of Mexico, 24 to 32 fathoms, *Albatross* Stations Nos. 2369, 2372, 2373 (type), 2387, 2389, 2390, 2405, 2406 (type of *townsendi productus*), 2407, 2409, 2410, 2411, 2412, 2414.

Yucatan, off Cape Catoche, 24 to 27 fathoms, *Albatross* Stations Nos. 2362, 2365, 2366.

St. Thomas, *Albatross*, and *Fish Hawk* Stations Nos. 6079, 6080, in 20 to 23 fathoms.

Porto Rico, Mayaguez Harbor, 4 to 6 fathoms, *Fish Hawk* Station No. 6065.

Culebra, 15 to 15.25 fathoms, *Fish Hawk* Stations Nos. 6087 and 6093.

Vieques, 15 to 16 fathoms, *Fish Hawk* Stations Nos. 6091 and 6092.

Bermuda, G. Brown Goode.



## Localities—Continued:

Brazil, Bahia, Hartt Expedition, Station No. 173.

Hawaiian Islands, French Frigate Shoal, 15 to 16 fathoms, *Albatross* Station No. 3969.

Southern part of Gulf of California, 9½ fathoms (type of form *mexicanus*), *Albatross* Station No. 2826.

Lower California (form *brevispinis*), M. Digue (Paris Museum).

Type of *S. townsendi*.—Cat. No. 38392, U.S.N.M.

Type of *S. townsendi productus*.—Cat. No. 9798, U.S.N.M.

Type of *S. townsendi mexicanus*.—Cat. No. 38393, U.S.N.M.

*S. townsendi* is particularly close to *S. paraneomeris* Coutière, a form with basicerite unarmed above, which also presents variations in the armature of that article, as does an "*oxyceros*" form. The difference consists principally in the supernumerary ventral prominence of the dactyls, absent in *S. townsendi*, but very characteristic of the NEOMERIS group, where a great number of species possess it. *S. paraneomeris* is one of the most widely distributed species of the Indo-Pacific region.

## NEOMERIS Group.

## SYNALPHEUS FRITZMÜLLERI, new species.

Rostrum slender, quite distinct from the lateral spines, the margins nearly parallel for half their length; lateral spines with sharp points, generally a little shorter than the rostrum, reaching to the middle of the basal antennular article.

The articles of the antennule are in the proportion: 1.5, 1.1, 1, beginning at the base; the external flagellum is bifurcate beginning at the eighth article; the stylocerite equals one-half of the median antennular article.

The basicerite of the antennæ bears on the upper side a strong spine, laterally a longer spine, a little shorter than the stylocerite; the antennular scale is narrow (6.6 times longer than wide), its sharp lateral spine reaching the extremity of the carpocerite, which surpasses the antennule by about half the distal article and is a little swollen and only three times longer than wide.

The external maxillipeds reach forward to the bifurcation of the external antennular flagellum.

The relative proportions of the large chela are: Fingers 1; total length 3.15 to 3.3; height 1.25; the anterior margin of the palm bears an obtuse prominence; the meropodite is 2.3 times longer than wide, its inferior margin terminating in a strong triangular point.

The proportion of the small chela to the large one is as 1 to 2.5. Its relative dimensions are: Fingers 1; total length 2.2; height 0.72; its meropodite also ends in a strong triangular lobe.

In the second pair the first article of the carpus is approximately equal to the four others taken together; the chela is a little shorter; the meropodite measures about 0.8 of the length of the carpus.

The relative proportions of the third pair are: Meropodite 2.33; carpus 1; propodite 2, or a little less; the meropodite is 3.5 times longer than wide, this proportion diminishing in adult females or in males of small size to 3.7; it reaches even 4 in a perfectly typical

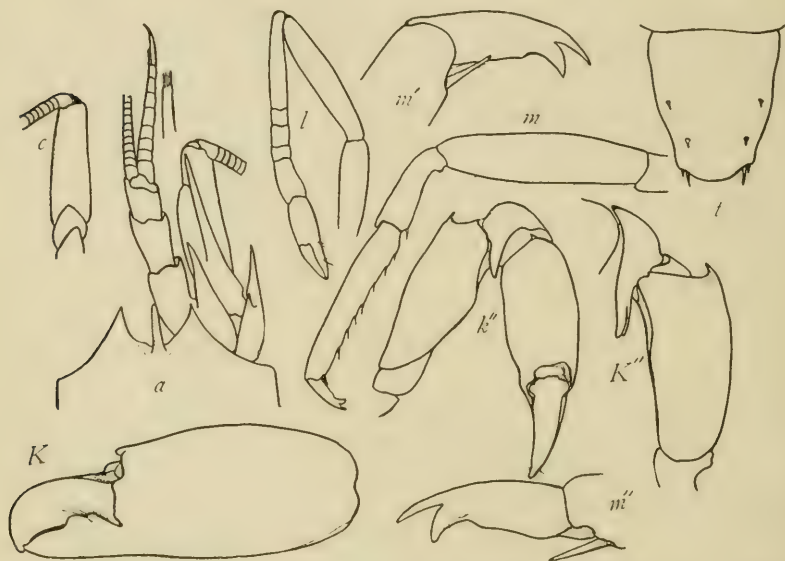


FIG. 18.—*SYNALPHEUS FRITZMÜLLERI*. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *K'''*, CARPUS AND MERPODITE OF LARGE CHELIPED; *k'''*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *m''*, REVERSE OF SAME; *t*, TELSON.

female from Cape Florida; the two hooks of the dactyl are divergent, the ventral nearly twice as thick as the dorsal, with the anterior margin more convex; it does not directly continue the inferior margin of the dactyl, rejoining it by a concave curve of short radius in such a manner as to form a third obtuse prominence.

The telson has its posterior angles obtuse, its posterior margin bears twenty plumose hairs between the two pairs of habitual spines.

The eggs are of small size, and the larvæ are zoæ.

The typical specimens are from Florida, some of them living in sponges; the species is also met with in Porto Rico and in Jamaica. In these three regions the typical examples predominate, but the

species also occurs in the "*oxyceros*" form (subspecies *elongatus*), the lateral spine of the scaphocerite greatly exceeding the carpocerite of the antennæ, and the rostrum being frequently longer than the lateral spines. The subspecies *elongatus* seems to be almost the only one in Venezuela and Brazil. Some specimens received from M. Chaper (Venezuela), others received from Fritz Müller from Desterro, and a small specimen from Bahia (R. Rathbun, Hartt Explorations) are without exception *elongatus*. Aside from their longer antennal spine, these specimens have the carpocerite less thick (3.3 to 3.4 times longer than wide), and the feet of the third pair more slender, the meropodite being 3.8 to 4 times longer than wide; but this last character varies with the size, and also with the sex, in the typical specimens within a rather wide range. With the material at my disposal I can not form a conclusion as to the advisability of the specific separation of this *elongatus* form.

The species is also found in Lower California, from which locality I have been able to study a single male specimen collected by M. Diguët, which does not differ from the Florida specimens in regard to the antennæ; the feet of the third pair are slender, the meropodite being four times as long as wide; but I find the same figures among the small typical males of Florida, of corresponding size, so that I can not separate this specimen from Lower California, even as a distinct "race."

Named for the naturalist, Dr. Fritz Müller.

#### Localities:

##### Typical specimens—

Cape Florida, Edward Palmer, 1 specimen.

Key West, Union University collection, 2 specimens.

Key West, H. Hemphill, 2 specimens.

Marco, Florida, H. Hemphill, 10 specimens, male and female, types.

Florida, west coast, 28 fathoms, *Fish Hawk* Station No. 7123, 1 specimen.

St. Thomas, *Albatross*, 1 specimen.

Mayaguez, Porto Rico, *Fish Hawk*, 4 specimens.

Lower California, M. Diguët (Paris Museum), 1 specimen.

##### Subspecies *elongatus*—

South Carolina, Mouth of Bull Creek, *Fish Hawk*, 1 specimen, type.

Florida, Eastern Dry Rock, Edward Palmer, 1 specimen.



FIG. 19.—SYNALPHEUS FRITZMÜLLERI ELONGATUS. a, FRONTAL AND ANTENNAL REGION.



## Localities—Continued:

Subspecies *elongatus*—Continued—

Florida, St. Martins Reef, Lieut. J. F. Moser, U. S. N.,  
1 specimen.

Florida, H. Hemphill, 1 specimen.

Florida, Key West, Union University collection, 1 specimen.

Jamaica, *Albatross*, 3 specimens.

Venezuela, M. Chaper, Paris Museum.

Bahia, Hartt Explorations, R. Rathbun, 1 specimen.

Desterro, Fritz Müller, Paris Museum.

Type of *S. fritzmuelleri*.—Cat. No. 6970, U.S.N.M.

Type of *S. fritzmuelleri elongatus*.—Cat. No. 38394, U.S.N.M.

## SYNALPHEUS HEMPHILLI, new species.

The species is very like the preceding, the differences being as follows:

The rostrum is always much longer (about twice) than the lateral spines; the feet of the third pair are a little shorter and thicker,

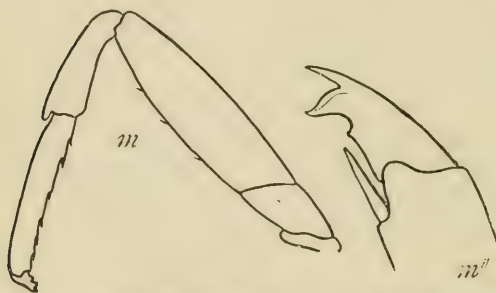


FIG. 20.—SYNALPHEUS HEMPHILLI. *m*, FOOT OF THIRD PAIR, BERMUDAS; *m''*, EXTREMITY OF FOOT OF THIRD PAIR, ALBATROSS STATION NO. 2409.

their relative proportions being, carpus 1; meropodite 2.5; propodite about 2; the meropodite is 3.5 times longer than wide; on the dactyl the ventral hook is perpendicular to the lower border and its margins form a double curve, convex, then a little concave to the point; behind, the very marked third prominence forms

a right angle at the summit, projecting a little in a spine.

It is therefore almost solely the form of the hook which distinguishes the two species, for the chela of the first pair, the telson, and the carpocerite are quite alike; this character of the dactyls is not only very marked, but perfectly constant in presence and in degree.

There is in this species, as in the preceding, an "*oxyceros*" form, in which the antennal scale equals the antennule, its lateral spine much exceeding the carpocerite. The resemblance of these two forms to *S. nilandensis* and *S. nilandensis oxyceros* Coutière, of the Maldives, is extremely close. The differentiation from *S. nilandensis*, in which the supraorbital spines are equal to the rostrum, the ventral hook of the dactyl is very strong, the supernumerary hook very dis-

tinct and spinous, is relatively easy; but in *S. nilandensis oxyceros* these last differences have entirely disappeared, the only ones persisting being the greater length of the supraorbital spines, that of the lateral spine of the basicerite, and lastly the presence of a row of five spines on the meropodite.

A large female specimen from the Bermudas of *S. hemphilli longicornis* is particularly interesting in this regard; the meropodite of the left foot of the third pair bears a well developed spine; the rest of the series is wanting; the opposite member is quite unarmed, but the suggestion arising from this circumstance is none the less instructive, as it shows to what degree the parallelism between the Indo-Pacific and the American forms may be carried. The "*oxyceros*" forms of the species *S. nilandensis* and *S. hemphilli* apparently represent the first evidences of divergence of certain species originally common to two regions; judging by the much greater number of species in the Indo-Pacific region, and also from the fact that there only are found the forms with spinulous meropodites, one might infer that that region was the center of dispersion of the group.

*S. paraneomeris* Coutière possesses the same form of hook as *S. fritz-mülleri*, from which it is most readily separated

by having the basicerite not spinous above; on the other hand, *S. paraneomeris* is no less closely related to *S. townsendi* Coutière, the basicerite of which is unarmed above, but the dactyls of which have no ventral supernumerary prominence; so that the two groups, the NEOMERIS group and the PAULSONI group, have in these three species a very evident point of approximation.

Named for Mr. Henry Hemphill, who has added largely to the Alpheidæ in the U. S. National Museum.

#### Localities:

West coast of Florida, 21 to 28 fathoms: *Albatross* Station No. 2409, 2 specimens, type; *Fish Hawk* Station No. 7123, 1 specimen; *Fish Hawk* Station No. 7124, 1 specimen (type of *longicornis*.)

Bermudas, G. B. Goode, 2 specimens (*longicornis*.)

Type of *S. hemphilli*.—Cat. No. 9817, U.S.N.M.

Type of *S. hemphilli longicornis*.—Cat. No. 38395, U.S.N.M.

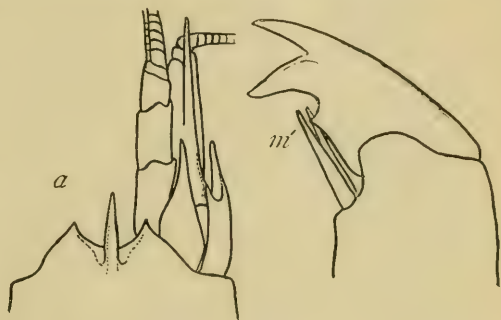


FIG. 21.—SYNALPHEUS HEMPHILLI LONGICORNIS. *a*, FRONTAL AND ANTENNAL REGION; *m'*, EXTREMITY OF THIRD FOOT.

## SYNALPHEUS NOBILII, new species.

This species is represented only by a single male specimen; I do not hesitate, however, to consider it distinct from *S. fritzmuelleri*. The differences which separate the two species (comparing two specimens of the same sex and of the same size) are the following:

The carpus of the small chela is more massive, its width exceeding that of the palm (proportion 1.12 instead of 0.9, as in *S. fritzmuelleri*).

The second pair is shorter and thicker, the carpus being six, instead of eight, times as long as wide. Furthermore, the first segment of the carpus is shorter than the sum of the four following.

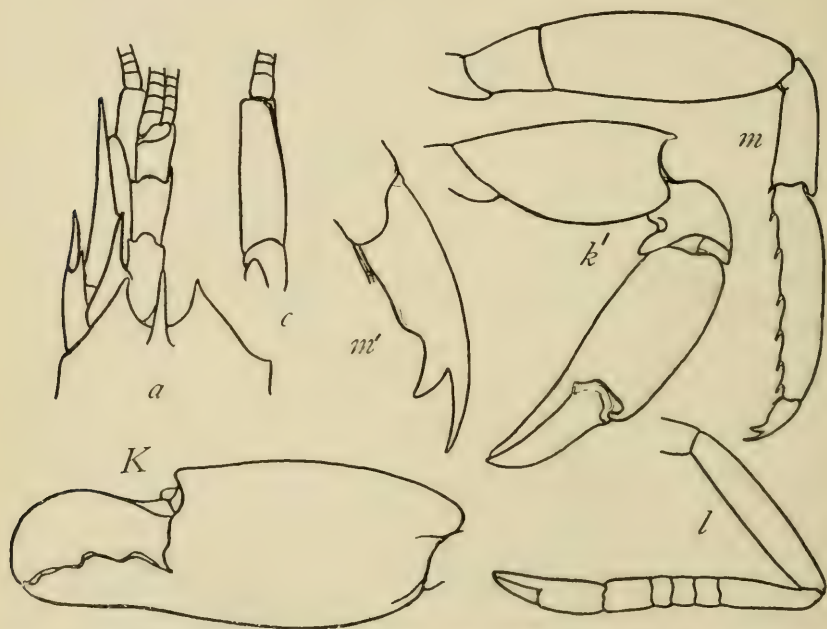


FIG. 22.—SYNALPHEUS NOBILII. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR.

The third pair is much more massive; the relative proportions being; Carpus 1; propodite 1.8; meropodite 2 (instead of 1, 2, 2.33); the meropodite is only 2.8 times as long as wide, instead of 4 times, as in *S. fritzmuelleri*.

I find no other difference, either in the carpocerite, in the dactyl of the third pair, or in the telson.

Named for Dr. Joseph Nobili, the carcinologist.

*Locality*.—St. Helena, Ecuador, one male specimen, 25 mm. long (M. Festa; Paris Museum).

I would remind the reader that *S. fritzmuelleri* is represented in the Paris Museum by a specimen from Lower California collected by



*M. Diguët*, which is absolutely typical and which it is impossible to separate as a distinct "race," a rare circumstance among the Synalpheids.

On the other hand, *S. nobilii* is very easily distinguished from *S. sanlucasi*, in which all the appendages, namely, the antennules, the spines of the basicerite and of the anterior margin, the large chela, the feet of the second pair, and the feet and even the dactyls of the third pair are much shorter and more massive.

SYNALPHEUS SANLUCASI, new species.

Species of each of the specific groups composing the genera *Alpheus* and *Synalpheus* are often parallel to species of closely allied



FIG. 23.—SYNALPHEUS SANLUCASI. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR.

groups in the characters upon which the separation of specific forms is based; as, for example, in the presence or absence of the superior spine of the basicerite or of the antennal scale, the slender or swollen form of the carpocerite, the spinose or unarmed palm of the large chela, and slenderness or stoutness of the thoracic feet. When one of these characters has been recognized in the species of a given group one can almost prophesy the existence of another species provided with the opposite character. This is, moreover, a well-known fact in all genera which are rather numerous in species.

Thus, *S. sanlucasi*, a form very close to *S. fritzmülleri*, differs from it in the shortness and more massive form of all its appendages.

The frontal teeth are stronger, the rostrum, especially, being wider at the base; the articles of the antennule are approximately equal, and the proportion of total length to the width is only 4.25 instead of 5, as in *S. fritzmülleri*.

The basicerite has its superior spine placed higher than in the preceding species, so that it reaches the extremity of the basal antennular article, and makes the lateral spine short and stout. Although the scale of the scaphocerite is as long as in *S. fritzmülleri*, the proportion of its length to its width is only 6 instead of 6.6, on account of its stoutness. The carpocerite is of the same form as in the preceding species, and also exceeds the antennule.

The large chela has, for its relative dimensions, fingers 1, total length 2.88, height 1.33; the small chela is lacking in the type.

In the second pair the carpus is only 5.6 times longer than wide, instead of 8, as in *S. fritzmülleri*; the relative proportions are: First article of the carpus 1; sum of the four following ones 1.6; terminal chela 1.72, very different, therefore, from the proportions found in *S. fritzmülleri*; the meropodite measures 0.7 of the length of the carpus.

The proportions of the third pair are: Meropodite 1.65; carpus 1; propodite 1.56; the meropodite is only 2.53 times longer than wide.

The dactyl has practically the same form as in *S. fritzmülleri*, the differences being that the ventral hook is wider at the base, and the entire appendage is shorter than in the preceding species.

The telson has not suffered the same diminution as the appendages, the proportions of its length to its proximal and distal ends being respectively 1.4 and 2.33, instead of 1.15 and 2, as in *S. fritzmülleri*, the telson of which species is, therefore, wider and shorter.

The eggs are of the same size as are those of the preceding species.

*S. sanlucasi*, readily distinguishable from the two American forms *S. fritzmülleri* and *S. hemphilli*, is much more closely allied to a species which I collected at Djibouti, and to which I give the name *S. heroni*, the species occurring on the reefs of Héron. *S. heroni* is distinguished by the following points: The lateral spine of the basicerite slightly exceeds the extremity of the median antennular article, and the antennal scale is more reduced, the proportion of its dimensions being about 7.3; on the other hand, its lateral spine, as in the "*oxyceros*" forms of many species, considerably exceeds the carpocerite.

The proportions of the large chela are: Fingers 1; length 3.2; height 1.32, it being, therefore, less massive than that of *S. sanlucasi*.

The small chela has these proportions: Fingers 1; total length 2.6; height 1.08; it is 2.45 times smaller than the large chela; the meropodite is a little more than twice as long as wide. Compared to that of *S. fritzmülleri*, the small chela appears much stouter, and it would probably be the same with *S. sanlucasi*.

In the second pair, the first article of the carpus, the sum of the four following ones, and the terminal chela are practically of the same length; the carpus is 6.5 times longer than wide.



FIG. 24.—SYNALPHEUS HERONI. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR.

The proportions of the third pair are: Meropodite 2; carpus 1; propodite 1.6; the meropodite is 2.5 to 2.6 times longer than wide, and is therefore longer and thicker than in the species from Lower California.

Cape St. Lucas, Lower California; John Xantus; type, Cat. No. 6355, U.S.N.M.

#### BREVICARPUS Group.

##### SYNALPHEUS MINUS (Say).

*Alpheus minus* SAY, Journ. Acad. Nat. Sci. Phila., J, 1818, p. 245.

Teeth of the frontal border in the form of an equilateral triangle, the rostral tooth usually a little wider at the base, and sometimes very slightly longer, than the lateral teeth.

The proportions of the antennular articles are: 2, 1.5, 1; the relation of the total length of the stalk of the antennule to its width is 4.8 to 5; the stylocerite reaches the distal third of the median article; the external flagellum bifurcates only at the tenth article.



Basicerite of the antennæ distinctly spinous above, the spine always longer than wide at the base; the lateral spine reaches to the extremity of the basal article of the antennule.

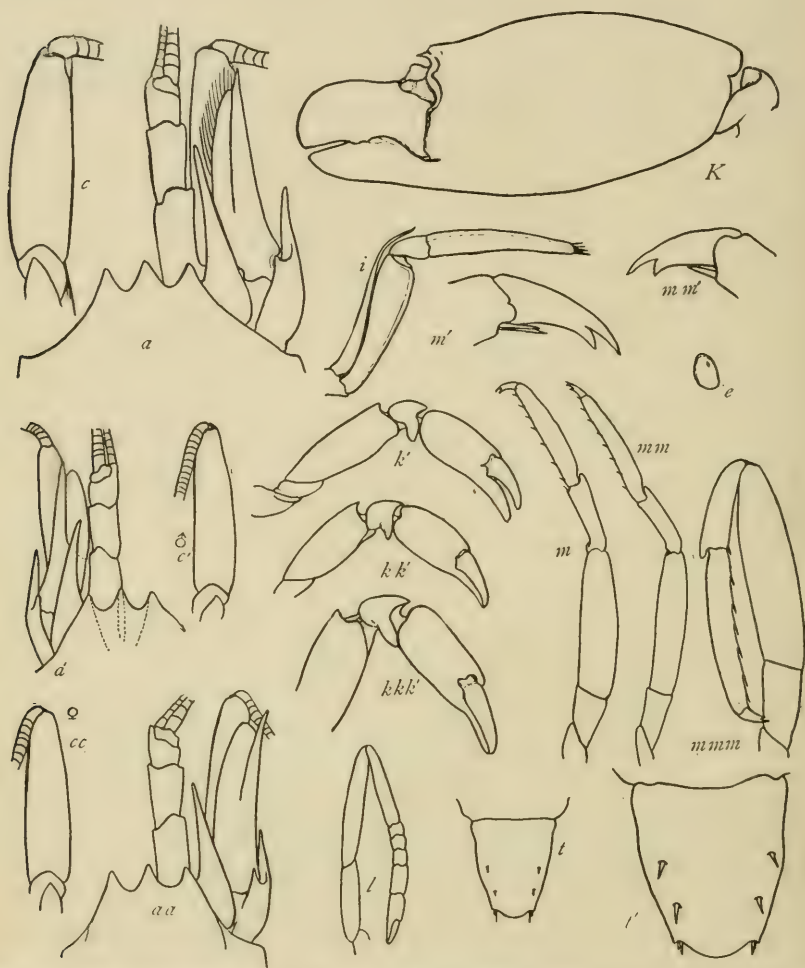


FIG. 25.—SYNALPHEUS MINUS. *a*, FRONTAL AND ANTENNAL REGION, TYPICAL; *a'*, FRONTAL AND ANTENNAL REGION, SPECIMEN FROM BERMUDAS WITH BASICERITE SPINOUS ABOVE; *aa*, FRONTAL AND ANTENNAL REGION, SPECIMEN FROM STATION NO. 7123 WITH CARPOCERITE MORE SLENDER; *c*, CARPOCERITE, TYPICAL; *c'*, CARPOCERITE, MALE, STATION NO. 7123; *cc*, CARPOCERITE, FEMALE, STATION NO. 7123; *e*, EGG; *i*, OUTER MAXILLIPED; *K*, LARGE CHELA, TYPICAL; *k'*, SMALL CHELIPED OF FIRST PAIR, S. BREVICARPUS; *kk'*, SMALL CHELIPED OF FIRST PAIR, TYPICAL; *kkk'*, SMALL CHELIPED OF FIRST PAIR, TYPICAL (ANOTHER SPECIMEN); *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR, TYPICAL; *mm*, FOOT OF THIRD PAIR, S. BREVICARPUS; *mmm*, FOOT OF THIRD PAIR, STATION NO. 7123; *m'*, DACTYL OF THIRD PAIR, NOT TYPICAL; *m m'*, DACTYL OF THIRD PAIR, TYPICAL; *t*, TELSON, S. BREVICARPUS; *t'*, TELSON, TYPICAL.

The antennal scale is narrow (proportion of length to width 7, and up to 8.5), its inner border making a very obtuse angle and not a regular curve; the lateral spine is a little longer than the peduncle of

the antennule, shorter than the carpocerite, which last is a little depressed, the proportion of its length to its width being about 3.7; it exceeds the antennule by half or even two-thirds of the distal article.

The large chela is regularly ovoid; its measurements, taken along the infero-external side, are: Fingers 1, total length 3.5; height 1.35; there is on the supero-internal side, on the anterior margin of the palm, near the articulation of the finger, a strong, sharp, and rather slender spine.

The small chela is in the proportion of about 2.7 to the preceding; its relative dimensions are: Fingers 1; total length 2.25; height 0.8; the fingers terminate in a simple point; the carpus is short, scarcely a fourth of the entire cheliped; the meropodite is 2.5 times longer than wide, its superior margin terminated by a trihedral prominence, not spinous.

In the second pair the proportion between the length and width of the carpus is about 9.5; the meropodite is only 0.75 of the length of the carpus.

The proportions of the third pair of feet are: Meropodite 2.2; carpus 1; propodite 1.6 to 1.7; the proportion between the length and the width of the meropodite is approximately 4, often a little less; the dactyl is a little curved, long, its hooks are almost parallel, the dorsal nearly twice as long as the ventral.



FIG. 26.—SYNALPHEUS MINUS BAHIENSIS. *a*, FRONTAL AND ANTENNAL REGION; *k'*, SMALL CHELIPED OF FIRST PAIR; *m'*, DACTYL OF THIRD PAIR.

The length of the telson equals 1.06 times the width at the base, and 1.84 times its distal margin, which is regularly convex and bears about twenty plumose hairs and two pairs of feeble spines.

The eggs are of small size (0.6 mm. in the nauplius stage, subsequently up to 1 mm.), and give rise to zoëæ.

The length of the species does not exceed 25 mm.

The typical specimens come from the region of the Bahamas and Florida, but the species extends to the Bermudas and southward to Brazil; some specimens from this last locality differ from the types and may be separated as form *bahiensis*; the basicerite of the antennæ has its lateral spine very slender, its superior spine long and strong, the lateral spine of the scaphocerite also slender, being as long as the carpocerite; the small chela is more swollen than in the typical specimens, the proportions being, fingers 1; total length 2.8; height

1 to 1.09; the proportion between the length and the width of the meropodite is 2.1 instead of 2.5; the dactyls, in the third pair especially, have their two hooks almost equally strong and long.

The strong superior spine of the basicerite, and also the greater thickness of the small chela, are found again, less marked, in some specimens from the Bermudas and from Florida, which it would be hardly advisable to separate as a distinct form. A specimen from Sarasota Bay, Florida, has an abnormal small claw, approximating the large one in its proportions; the fingers measure only one-third of the total length, and the anterior border is spinous. This tendency to the reestablishment of the symmetry of the two claws is not very rare in the Alpheidæ; and, although leading to the same results, it is

diametrically opposed to the cases of hypotypic regeneration, of which also examples are known.

Other very interesting specimens differ markedly from the types by the width of the antennal scale, only 7.3 times longer than wide, recalling by its form that of *S. brevicarpus*. Other characters of the species are in these specimens weakened in the same way; for example, the carpus is a little less swollen, the proportion of its length to its width (3.7) declining to 4 in

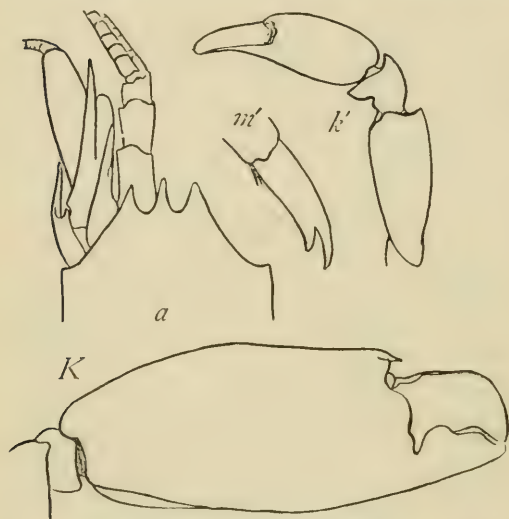


FIG. 27.—*SYNALPHEUS MINUS ANTILLENsis*. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *m'*, DACTYL OF THIRD PAIR.

the male; of the members of the second pair the carpus is 10 times longer than wide. On the other hand, the dorsally strongly spinous basicerite, the thick meropodite of the third pair, the telson widened at its distal end, and the form of the chelæ of the first pair, permit the determination of these examples as *S. minus*. They indicate in what way the variation giving rise to the species *brevicarpus* is accomplished.

Among the other varieties of *S. minus*, it seems to me possible to separate a form *antillensis*. The specimens which are referred to this form come mainly from Porto Rico and St. Thomas. They differ from the types in the frontal teeth, which are long and narrow, especially the rostrum, and in the antennule, which is only 4.2 to 4.3

times as long as wide; the basicerite is not more spinous above than in the typical specimens; the carpocerite is longer, surpassing the antennules by the length of the distal article, and, especially, more ovoid (proportion 3.2 or even 3.15); the antennal scale is also a little wider than in the types; the small chela, as in the form *bahiensis*, is more swollen than in the types; it has, as its proportions, fingers 1; total length 2.38; height 0.9; there are no differences either in the form of the large chela, of the members of the second and third pairs, or in the telson.

In some specimens, especially among those from St. Thomas, the dactyls of the third pair are very slender, with the superior margin only slightly convex, and the superior hook strong. I have not a sufficient series to enable me to judge of the importance of this character.

The specimens of the form *antillensis* are all of small size, 15 mm. in length at the most. The eggs are as in the typical specimens.

#### Localities:

South Carolina, 15 miles southeast of Charleston, in fragment of madrepora, R. E. Earll.

#### Florida:

Cape Florida, Edward Palmer.

Elliotts Key, lat.  $26^{\circ} 33' N.$ , long.  $83^{\circ} 10' W.$ , 28 fathoms, *Fish Hawk* Station No. 7123 (specimen approaching *brevicarpus*).

Harbor Key.

Salt Pond Key, Stock Island.

Eastern Dry Rock.

Key West, Union University collection.

Dry Tortugas.

Florida Bay, Edward Palmer.

Two miles west of Cape Romano, 15 to 18 feet, Lieut. J. F. Moser, U. S. N.

Marco, H. Hemphill.

Sarasota Bay (specimen with small chela anomalous), Union University collection.

Anclote (specimen approaching *brevicarpus*), Thomas Low.

Florida Banks, lat.  $28^{\circ} 56' N.$ , long.  $28^{\circ} 15' W.$ , 12 feet, Lieut. J. F. Moser, U. S. N.

St. Martins Reef, Lieut. J. F. Moser, U. S. N.

#### Bahamas:

Andros Island, in sponges, F. Stearns collection.

Green Cay, Geographic Society of Baltimore.

St. Thomas, 20 to 23 fathoms, *Fish Hawk* Station No. 6079 (type of form *antillensis*),



## Localities—Continued:

Porto Rico (form *antillensis*):Playa de Ponce, *Fish Hawk*.Humacao,  $9\frac{1}{2}$  fathoms, *Fish Hawk* Station No. 6099.

Bermudas (specimen with basicerite very spinous), G. B. Goode.

Brazil, Plataforma, Bahia (type of form *bahiensis*), R. Rathbun, Hartt Explorations.Type of *S. minus bahiensis*.—Cat. No. 38396, U.S.N.M.Type of *S. minus antillensis*.—Cat. No. 38397, U.S.N.M.

## SYNALPHEUS DIGUETI, new species.

This species represents the *BREVICARPUS* group on the coast of Lower California, where it has not previously been found. It is, consequently, a very important extension of the geographic distribution of this group, which thereby ceases to be an exception from the general rule. Just as the *LEVIMANUS* group possesses at least one Indo-Pacific species, it will also be found that the *BREVICARPUS* group has met in that region of the globe conditions inducing specific differentiation.

*S. digueti* is very near *S. minus* (Say); the differentiation is difficult except between adult specimens, and the more mature, the easier is the determination. The characters of the males are more decided than are those of the females. In the males the differences between *S. digueti* and *S. minus* are the following: (1) The antennule is 6 times longer than wide instead of 5 times, as in the males of corresponding size of *S. minus*; (2) the carpocerite is 3.5 times longer than wide instead of 3.7 times, and the lateral spine of the scaphocerite is a little shorter than the antennule; (3) the meropodite of the third pair of feet is 3.5 times longer than wide instead of 3.75 times.

In the females the antennule is not more than 5.8 times as long as wide, and the spine of the scaphocerite slightly exceeds the antennule, so that the tangible differences from the females of *S. minus* become almost none. However, the carpocerite is somewhat thicker, 3.54 to 3.58 times longer than wide, while this proportion reaches 3.7 to 3.75 in the females of *S. minus*; there is also a very slight difference in the thickness of the meropodite of the third pair, where the proportions are nearly 3.5 in *S. minus* and 3.3 in *S. digueti*.

There is also in both sexes a slight difference in the meropodite of the small cheliped; this is at the most as wide as the palm, and generally a little narrower in *S. minus* (proportion 0.92 to 0.96); in *S. digueti*, on the other hand, it is wider (proportion 1.1 to 1.13).

The specimens which have just been considered do not exceed 25 mm. in length; in one large female measuring 30 mm. (also collected by M. Diguët) the characters are much more clearly indicated,

the antennules especially, markedly slender, being 6 times longer than wide, as in the male; in the largest females of *S. minus*, which are of equal size, this proportion never exceeds 5; the carpocerite is only 3.35 times longer than wide instead of 3.7 times, as in the largest female of *S. minus*.

This specimen presents, moreover, a very peculiar form of rostrum, the point being shorter, and, particularly, much narrower than the lateral teeth. I have noticed in a male a tendency toward this shape. The lateral spines are very slightly longer than the rostrum, forming

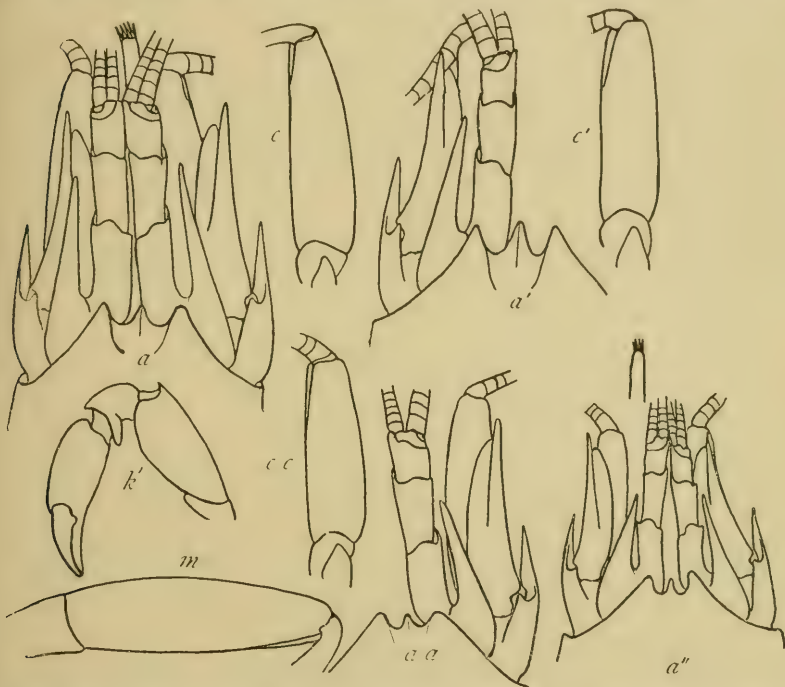


FIG. 28.—SYNALPHEUS DIGUETI AND *S. DIGUETI ECUADORENSIS*. *a*, FRONTAL AND ANTENNAL REGION OF *S. DIGUETI*, MALE OF MEDIUM SIZE; *a'*, FRONTAL AND ANTENNAL REGION OF *S. DIGUETI*, FEMALE OF MEDIUM SIZE; *a''*, FRONTAL AND ANTENNAL REGION OF *S. DIGUETI*, FEMALE OF LARGE SIZE; *aa*, FRONTAL AND ANTENNAL REGION OF *S. DIGUETI ECUADORENSIS*, MALE; *c*, CARPOCERITE OF *S. DIGUETI*, MALE; *c'*, CARPOCERITE OF *S. DIGUETI*, FEMALE; *cc*, CARPOCERITE OF *S. DIGUETI ECUADORENSIS*; *k'*, SMALL CHELIPED OF FIRST PAIR OF *S. DIGUETI*; *m*, MEROPODITE OF THIRD PAIR OF *S. DIGUETI*.

a prominence exceeding it in height, so that the rostrum seems to be situated on a lower plane.

The eggs are of the same size as those of *S. minus* and also give rise to zoëæ.

Twelve specimens, male and female, from Lower California (M. Diguët, Paris Museum).

One very interesting form of this species is represented by two specimens, male and female, from Ecuador. The differences between the

male and female are very slight; the frontal teeth are very short, and the rostrum a little shorter and weaker than the lateral teeth, especially in the male. In both cases the antennule is 5.5 times as long as wide; the lateral spine of the scaphocerite is as long as the antennule; the carpocerite exceeds it very little in the female, a little more in the male, and is very much swollen, only 3.5 times as long as wide in the male, or 3.3 times in the female; the meropodite of the third pair is 3.25 times as long as wide in both specimens.

This form of *S. digueti* (which might be distinguished under the name of *ecuadorensis*) makes the distribution of the BREVICARPUS group much like that of the PAULSONI group, which has representatives in Lower California and Chile, in Brazil and Florida, as well as in the West Indies. I have shown in the introduction to this paper what interest attaches to the presence or absence of the species of the BREVICARPUS group elsewhere than on the American coasts, because of their close relations of kinship with the species of the PAULSONI group.

St. Helena, Ecuador; M. Festa; 2 specimens, male and female (Paris Museum).

Named for M. Diguët.

#### SYNALPHEUS BREVICARPUS (Herrick).

*Alpheus sauleyi* var. *brevicarpus* HERRICK, Mem. Nat. Acad. Sci., V, 1891, p. 383.

The species is also very like *S. minus*, from which it is distinguished by the following characters:

The proportions of the antennular articles are 1.8, 1.7, 1; the proportion of the length to the width of the antennule is at least 5.5.

The basicerite is not spinous above; it bears an angular prominence, at most as long as wide at base.

The scaphocerite has a very wide scale, with the border regularly curved within; it is from 5.5 to 6.4 times longer than wide; the hairs which border it are at least twice as long as those in *S. minus*; but, on the other hand, the lateral spine, shorter and more obtuse, does not reach the end of the antennular stalk.

The carpocerite is sensibly 4 times as long as wide and more cylindrical than in *S. minus*.

The large chela has the following relative dimensions: Fingers 1; total length 3; height about 1.15, varying to 1.2. In the large specimens the movable finger presents a second obtuse prominence between the point and the molar processes of the lower margin; the palm is less regularly ovoid than in *S. minus*, and more tapering on the proximal side.

The small chela measures a third of the preceding; the relative dimensions are: Fingers 1; total length 2.35 to 2.4; height 0.65 to

0.7 (a little narrower therefore than in *S. minus*). The meropodite is similar in the two species (proportion 2.5).

In the second pair the proportion of the length to the width of the carpus is about 12:1; furthermore, the meropodite is 0.85 of the length of the carpus.

The proportions of the feet of the third pair are the same as in *S. minus* save for the meropodites, in which the proportion between the length and the width reaches 4.25.

The length of the telson reaches from 1.06 to 1.15 times its large base, always more than twice (2.05 to 2.23 times) its small base, the article being visibly narrower than in *S. minus*.

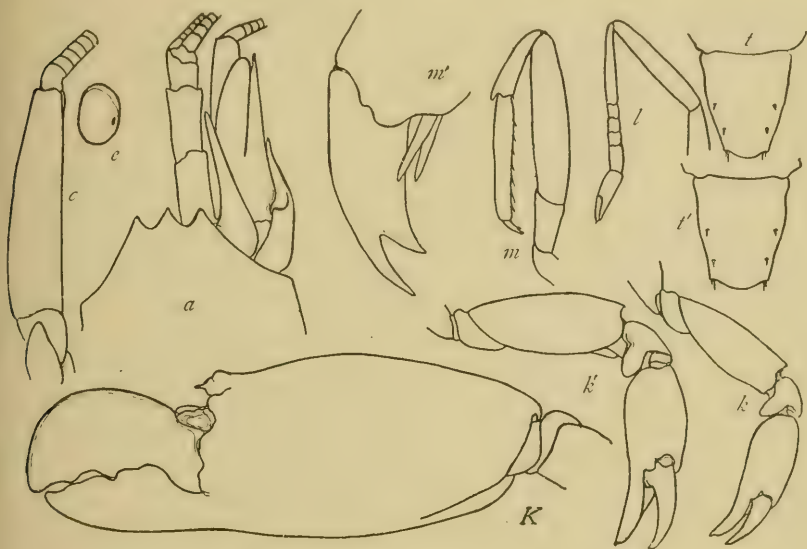


FIG. 29.—SYNALPHEUS BREVICARPUS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CAROCERITE; *c*, EGG; *K*, LARGE CHELA; *k*, SMALL CHELIPED OF FIRST PAIR, MALE; *k'*, SMALL CHELIPED OF FIRST PAIR, MALE, *S. MINUS* (FOR COMPARISON); *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON; *t'*, TELSON, *S. MINUS* (FOR COMPARISON).

The eggs are of large size and give rise to mysis larvæ provided with all their appendages, comprising the chelipeds of the first pair, which are already very unequal, and those of the second pair, in which the carpus is already segmented.

The size may reach 36 or even 38 mm. (female).

There occurs a remarkable variety of this species represented by some specimens from Key West and also from Porto Rico (*guerini*). The frontal teeth are long, especially the rostrum, which last slightly surpasses the lateral teeth and is also wider at the base; the margins are strongly concave outside instead of being straight, as in typical specimens; the basicerite of the antenna is a little more spinous



above; the scaphocerite has its lateral spine more elongate, so that it attains the length of the carpocerite.

In these characters the specimens recall the form *antillensis* of *S. minus*, but they are perfectly distinct from it; it is as if the two species, while themselves closely allied, had effected in the same way parallel variations. While in the variety *antillensis* of *S. minus* the carpocerite is ovoid, the feet of the second and third pairs are strong, and the telson is wide; in the variety *guerini* of *S. brevicarpus* the carpocerite is slender and cylindrical (proportion 1:4 and even 1:4.4), the carpus of the second pair is 12 times as long as wide, the meropodite of the third pair is 4.5 to 4.7 times as long as wide, and the telson is narrow, as in the typical specimens of the species.

The chelæ of the first pair are those of *S. minus*. The proportions for the small chela are: Fingers 1; total length 2.26; height 0.75.

I have been able to see the eggs on only one female of very small size, and infested with a Bopyrid; they are of the same volume as those of *S. minus*. According to the appearance of the mature ovary of another female, I think that it is their normal size, and that this is besides another character which distinguishes these specimens from *S. brevicarpus*, at the same time approaching *S. minus*.

I give to the variety the name of *guerini* because it perhaps corresponds to *Alpheus sauleyi* of Guérin. In the figure by that author<sup>a</sup> the rostrum is longer than the lateral spines and the



FIG. 30.—SYNALPHEUS BREVICARPUS GUERINI. *a*, FRONTAL AND ANTENNAL REGION; *a'*, FRONT; *c*, CARPOCERITE.

basicerite appears to be spinous above. It is proper to note that in the nomenclature the trinomial appellation does not imply that this form is derived from *S. brevicarpus*; the contrary would be as plausible; the forms with large eggs, always rare, may be considered as derived from the species in which the eggs have the usual small size.

#### Localities:

##### Florida:

Elliotts Key, J. E. Benedict.

Harbor Key, Union University collection.

Key West, H. Hemphill, Bean and King, Eliot, Union University collection.

<sup>a</sup> Hist. Cuba de Ramon de la Sagra, Pt. 2, VII, 1857, p. 18, pl. II, fig. 8.

## Localities—Continued:

## Florida—Continued:

Key West (form *guerini*), Union University collection.

Dry Tortugas, Eastern Dry Rock, Salt Pond Key, and

Florida Bay, Edward Palmer.

## Bahamas:

Andros Island (some coming from sponges), F. Stearns collection.

Green Cay, B. A. Bean.

## Porto Rico:

Off Humacao,  $9\frac{1}{2}$  fathoms, *Fish Hawk* Station No. 6099 (type of form *guerini*).

Type of *S. brevicarpus guerini*.—Cat. No. 24797, U.S.N.M.

## LÆVIMANUS Group.

## SYNALPHEUS LONGICARPUS (Herrick).

*Alpheus saulcyi* var. *longicarpus* HERRICK, Mem. Nat. Acad. Sci., V, 1891, p. 383 (part).

I have previously shown that this species is closely allied, not to *A. brevicarpus* Herrick, but to the European species *S. lævimanus* (Heller). However, it is not synonymous with the latter, any more than any of the forms which follow. I have indicated in the introduction to this work why it was necessary to break up into several distinct specific forms *A. saulcyi* var. *longicarpus* Herrick. I have retained the original name for the above species, as it appears to me to be the most abundant of the LÆVIMANUS group on the American coasts.

The frontal border has three unequal teeth, the median narrow, a little longer, the lateral having from 2 to 2.5 times the width of the median part of the rostrum; their interspaces are in form of a V, with borders little divergent.

The basal antennular article is the longer; its anterior margin is less emarginate on the inside than in the greater part of the species of the group. The relative lengths of the articles are 2, 1.5, 1. The antennule is 5 times as long as wide; the flagella are slender, the external bifurcates after the sixth article.

The stylocerite reaches the distal third of the basal article. The basicerite has its superior angle obtuse; its lateral spine reaches the extremity of the median article of the antennule. The scaphocerite is almost always devoid of a scale in the male; it bears one of variable length in the female, but it hardly surpasses the extremity of the basal antennular article, and it is never more than half the width of the lateral spine, which is very strong, sharp, and exceeds the antennule by about half its distal article.

The carpoperite is cylindrical, rather slender, curved outward, and surpasses the antennule by the length of the distal article; it is 5 times as long as wide, and sometimes up to 5.5 or 5.6 times.



FIG. 31.—*SYNALPHEUS LONGICARPUS*. *a*, FRONTAL AND ANTENNAL REGION, MALE AND FEMALE; *c*, CARPOPERITE; *K*, LARGE CHELA; *K'*, CARPUS AND MEROPODITE OF LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR, MALE AND FEMALE; *kk*, FINGERS OF SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR, MALE AND FEMALE; *m*, FOOT OF THIRD PAIR, MALE AND FEMALE; *m''*, DACTYL OF THIRD PAIR; *m'''*, DACTYL OF THIRD PAIR OF A VERY ADULT SPECIMEN; *p'*, FIRST PLEOPOD; *p''*, FOURTH PLEOPOD; *p'''*, FIFTH PLEOPOD; *t*, TELSON; *tt*, TELSON AND UROPODS, FEMALE; *u*, UROPOD.

The relative dimensions of the large chela are: Fingers 1; total length 4.1; height 1.5; T. L. : H. = 2.73:1. The margin of the palm presents forward a strong tubercle, ending in a fine point. The movable finger has its point out of the perpendicular. The palm

is prolonged behind, and the very small carpus is inserted below the principal axis of the ovoid palm. The meropodite, the superior border of which ends in a right angle, is 2.25 times longer than wide. In a comparison of the male and female, the large claws are in about the proportion of 1.3 to 1.

The small claw is, to the large one, in the proportion of about 2.5 in the female, of 3 in the male, so that it is apparently of the same size in both sexes; the relative dimensions are: Fingers 1; total length 3; height about 0.8; T. L. : H. = 3.75 : 1. The movable finger bears two teeth, the lower of which is the stronger; the fixed finger bears besides its point, two short angular prominences.

The carpus shows some rather remarkable variations; in the larger specimens it is constantly longer than the palm; it is usually a little shorter in medium or very small specimens of either sex. The total length of the chela being taken for a unit, the length of the carpus may vary from 0.74 to 0.56 and even 0.5; it is always shorter in the female. In every case its distal width remains equal to that of the chela. The meropodite is about 4 times as long as wide (4.4 in the male, 3.6 in the female of large size):

The second pair is notably stronger in the male (1.08), but of similar proportions in both sexes; the first segment of the carpus is shorter than the sum of the other 4 (proportion 1.2); the meropodite equals twice the first carpal segment. The terminal claw is longer, in the male, than the last 4 segments, but shorter in the female; it bears, especially in the male, about ten tufts of hair.

The third pair is also stronger in the male, where its relative dimensions are: Meropodite 2.33, carpus 1, propodite 1.7; the meropodite is 3.5 times longer than wide.

In the female these dimensions are: Meropodite 2.1, carpus 1, propodite 1.55, the meropodite being 3.8 times longer than wide. The ischiopodite is more slender and elongated also than in the male. The dactyl is short, one-sixth or more of the propodite; the two hooks are almost equal and divergent, the ventral normal to the lower border, a little thicker at the base than the dorsal, becoming proportionately longer in specimens of large size (female of 27 to 28 mm.). The sixth abdominal somite shows on either side of the telson a wide triangular point. The pleopods of the fifth somite have a very short base and a wide posterior expansion especially marked in the female, where it contributes to close the incubatory cavity. The anus is shown under the telson between two very prominent swellings. All the abdominal pleura of the male, even the second, end in a point. These last details are more marked in the *LÆVIMANUS* group than in any other, and especially in the two species *S. longicarpus* and *S. pectiniger*.

The telson has the following relative dimensions in the male: Small base (distal) 1; large base (proximal) 1.7; height 2.3. In the



female the large base is double the small. The posterior margin bears 4 spines, the inner a little longer, with 4 long plumose hairs between them, and 3 pairs of simple hairs inserted above the preceding. The uropods are larger in the male, the outer especially; the latter bears on its outer margin above the transverse suture a series of 7 to 8 teeth and a movable spine between the first two.

The eggs are of small size and the larvæ are zöææ. The species may be found in sponges, but it is not probable that such is its normal habitat.

I have been able to separate among the young males a rather large number of specimens different from the type and different also from the following species, *S. goodei*, with which, however, they agree in having a well-developed antennal scale. Compared to young male *longicarpus* of the same size, they are distinguished—

(1) By the antennal scale reaching the extremity of the second article of the antennule; (2) by the carpocerite a little thicker (proportions: 1:4.6, 4.9 or 5, instead of 1:5.5 or 5.6); (3) by the large chela in which the anterior border of the palm ends in an obtuse point, conical and strong; (4) by the telson a little narrower at the base; this is contained 1.8 times in the height instead of 1.4 times.

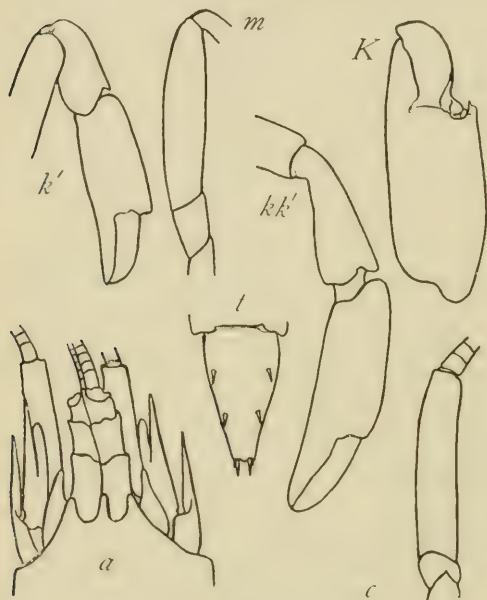


FIG. 32.—SYNALPHEUS LONGICARPUS APPROXIMA. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR OF A YOUNG SPECIMEN; *kk'*, SMALL CHELIPED OF FIRST PAIR OF AN ADULT; *m*, MEROPODITE OF THIRD FOOT; *t*, TELSON.

Excepting in the form and size of the antennal scale, which are quite similar, these specimens are also shown to be very distinct from the males of *S. goodei* of the same size—

(1) By the carpocerite a little thicker (the same difference as with *S. longicarpus*); (2) by the large chela, invariably shorter and thicker in *S. goodei*, even in the young, not exceeding 12 mm. in length (proportion of thickness 1.1); (3) by the small chela, of which the carpus and the palm are shorter in *S. goodei*; their sum equals only 4 times the height of the palm instead of 5 times, as in the specimens

under discussion. The meropodite is also thickened in the same proportion in *S. goodii*: (4) by the meropodites of the third pair longer and more slender (proportion 1:4.2 instead of 1:3.5).

I have met only one adult male which appears to be referable to this form; the carpus of the small cheliped measures 0.54 of the total length of the chela. It is accompanied by several other specimens, but they are too incomplete to permit of the appreciation of the fine distinctions which separate *S. goodii* and *S. longicarpus*.

I hesitate to consider this form as specifically distinct from *S. longicarpus*, although the adult specimen differs from it only by the presence of an antennal scale; this is, however, much reduced. Neither is the form of the anterior palmar tubercle very constant in *S. longicarpus*, as the small spine which terminates it may be absent. It seems to me sufficient to distinguish these specimens as form *approxima*.

#### Localities:

##### *S. longicarpus*—

##### North Carolina:

Off Cape Fear, 15 fathoms, *Albatross* Station No. 2623, 20 to 30 specimens.

##### Gulf of Mexico:

Lat.  $27^{\circ} 4' N.$ , long.  $83^{\circ} 21' 15'' W.$ , 26 fathoms, *Albatross* Station No. 2409, 7 specimens.

Lat.  $26^{\circ} 33' N.$ , long.  $83^{\circ} 10' W.$ , 28 fathoms, *Fish Hawk* Station No. 7123, 1 specimen.

Lat.  $26^{\circ} N.$ , long.  $82^{\circ} 57' 30'' W.$ , 24 fathoms, *Albatross* Station No. 2413, 4,000 to 5,000 specimens.

##### Yucatan:

Off Cape Catoche, 25 fathoms, *Albatross* Station No. 2362, 20 specimens.

Off Cape Catoche, 21 fathoms, *Albatross* Station No. 2363, 15 to 20 specimens.

Jamaica, in massive black sponges, 10 to 12 fathoms, J. E. Duerden.

Curaçao, 2 specimens.

##### *S. longicarpus approxima*—

Gulf of Mexico, 26 fathoms, *Albatross* Station No. 2409, 4 specimens, type.

Gulf of Mexico, 24 fathoms, *Albatross* Station No. 2413, 2 specimens.

Gulf of Mexico, 26 fathoms, *Albatross* Station No. 2414, 4 larger specimens (mutilated).

Type of *S. longicarpus approxima*.—Cat. No. 38398, U.S.N.M.

## SYNALPHEUS GOODEI, new species.

The frontal margin very forcibly suggests that of the preceding species; the rostrum is quite a little longer than the lateral spines, and the latter are more completely triangular.

The articles of the antennule have as proportions, 2.3, 1.2, 1, the antennule being 5 times as long as wide; the basicerite of the antenna has its superior angle somewhat sharp; its lateral spine reaches the extremity of the median antennular article.

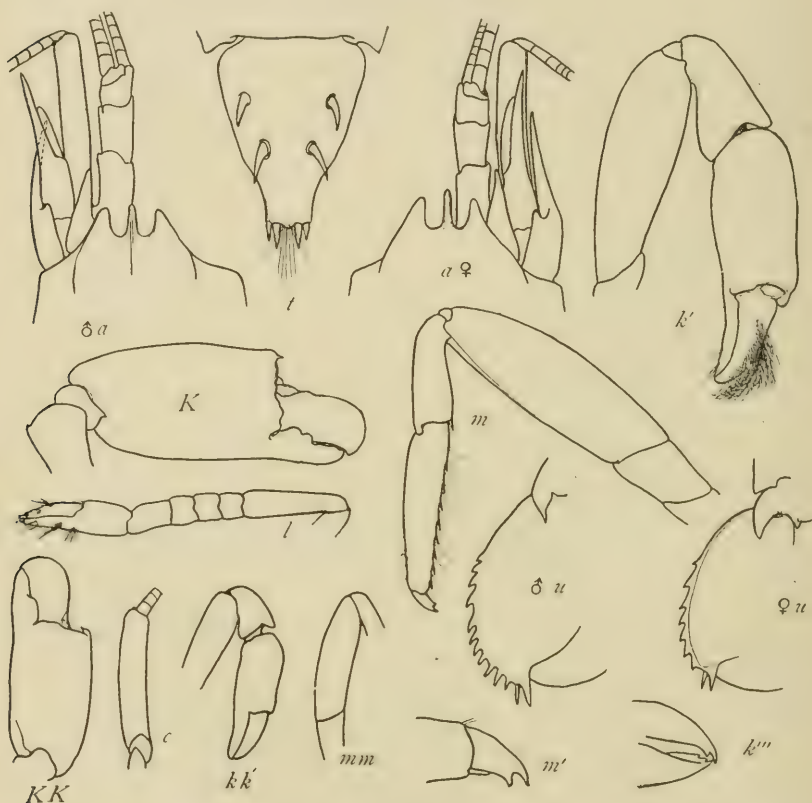


FIG. 33.—SYNALPHEUS GOODEI. *a*, FRONTAL AND ANTENNAL REGION, MALE AND FEMALE; *c*, CARPOCERITE OF A YOUNG SPECIMEN *a*; *K*, LARGE CHELA; *KK*, LARGE CHELA OF A YOUNG SPECIMEN *a*; *k'*, SMALL CHELIPED OF FIRST PAIR; *kk'*, SMALL CHELIPED OF FIRST PAIR OF A YOUNG SPECIMEN *a*; *k''*, FINGERS OF SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *mm*, MEROPODITE OF THIRD FOOT OF A YOUNG SPECIMEN *a*; *m'*, DACTYL OF THIRD FOOT; *t*, TELSON; *u*, UROPOD, MALE AND FEMALE.

The scaphocerite always possesses a scale, which is of the same dimensions in both sexes, and often reaches the middle of the distal antennular article; the lateral spine is as in the preceding species.

The carpopocerite is 5.2 times (in the young) to 5.7 to 6 times longer than wide.

<sup>a</sup> For comparison with *S. longicarpus approxima*, fig. 32.

The large chela has as its proportions, fingers 1; total length 3.5 to 3.6; height about 1.3; the relative total length is a little less in the female, but the difference in size is very slight; the form of the chela is quite different from that of *S. longicarpus*; the margins of the palm are nearly parallel, the anterior margin terminating in a strong tubercle which is prolonged by a point inclined downward; the carpus is inserted in the prolongation of the greater axis; the meropodite is proportionately stouter (proportion 2.05), its superior margin terminating in a prominent, not spinous, lobe.

The small chela has the following relative dimensions: Fingers 1; total length 2.8; height 0.96 to 1; the movable finger terminates in two short teeth; the carpus is always much shorter than in *S. longicarpus*; in the largest examples its length does not surpass 0.43 of the small chela, this proportion reaching 0.74 in the preceding species; in the young this proportion remains the same, while it is very variable in *S. longicarpus*; the carpus is always a little less thick than the palm, the margins of which are not parallel, as in *S. longicarpus*; the meropodite is a little more than 3 times as long as wide. I have found no sexual differences.

In the second pair, the first segment of the carpus, the sum of the four following and the terminal chela are all very nearly equal; the carpus is at least 7 times as long as wide.

The third pair has these proportions in the male: Meropodite 2.2; carpus 1; propodite 1.5 to 1.6; the meropodite is 3 to 3.2 times as long as wide; in the female these proportions become, respectively, 2.6; 1; 2; and the meropodite is nearly 3.5 times as long as wide, the entire appendage being more slender; the dactyl is short, very like that of *S. longicarpus*.

The second abdominal pleuron is not spinous in the male.

The telson has its wide base contained 1.24 times, and its small base about 4 times, in its height; the spines of the dorsal surface, especially in the male, are much stronger than those of the posterior border, the inner of which, a little the longer, include between them 4 plumose hairs and 2 groups of 3 simple hairs.

The uropods bear upon the outer border 8 teeth in the female and from 9 to 17 teeth in the male, the first and strongest of which prolongs the transverse suture; and there is also a movable spine placed between the two first teeth.

As in *S. longicarpus*, the eggs give rise to zoëæ.

The two species, which are very close to each other, are further connected through the forms which represent them on the Pacific coast. The Paris Museum possesses some specimens collected by M. Digue in the Gulf of California, which are distinguished from *S. goodei* by the total absence of an antennal scale and by the presence of 5 to 9 teeth on the external uropod even in the male, characters



which would ally them rather to *S. longicarpus*; but they approach *S. goodei* in having the small chela thicker than in *S. longicarpus*, as



FIG. 34.—SYNALPHEUS GOODEI OCCIDENTALIS. *a*, FRONTAL AND ANTENNAL REGION; *a'*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *m*, FOOT OF THIRD PAIR; *u*, UROPODS.

is shown in the following table, and in having the meropodite of the third pair thicker:

Species.	Ratio of total length to height in small chela.	Ratio of meropodite to small chela.	Ratio of length to width in meropodite of third pair.
<i>S. longicarpus</i> , female .....	3.5-3.6	4.0	3.8
<i>S. goodei</i> , female .....	3.0	3.0	3.5
<i>S. goodei occidentalis</i> , female .....	3.2	3.5	3.3-3.4

A female is especially like *S. goodei* in possessing a rudiment of an antennal scale, a stylocerite longer than the basal antennular article, the meropodites of the third pair more similar to those of the female of *S. goodei* (proportion 3.4), and lastly 12 spines on the outer uropod, as in the male of the last-named species. I propose to designate the example from the Pacific under the name of *S. goodei occidentalis*, remarking that the female last described would probably be found to be more distinct in a more extended series.

Named for the late Dr. George Brown Goode, Assistant Secretary in Charge of the United States National Museum.

## Localities:

*S. goodei*—

Gulf of Mexico, 34 fathoms, *Grampus* Station No. 5088, 1 specimen.

Tampa Bay,  $6\frac{1}{2}$  fathoms, *Fish Hawk* Station No. 7109, 1 specimen.

Near Colon, 34 fathoms, *Albatross* Station No. 2147, 1 specimen.

Bermudas, George Hawes, 2 specimens.

Bermudas, Harrington Sound, in sponges, George Hawes, 7 or 8 specimens.

Bermudas, G. Brown Goode, 20–30 specimens, type.

*S. goodei occidentalis*—

Lower California, Gulf of San José, M. Diguët, 7 specimens (Paris Museum).

Type of *S. goodei*.—Cat. No. 24821, U.S.N.M.

## SYNALPHEUS SANCTITHOMÆ, new species.

Although very like *S. goodei*, this species ought certainly to be separated from it.

The basicerite has an obtuse superior angle; its lateral spine does not reach the extremity of the median article of the antennule; the antennal scale is  $1\frac{1}{2}$  times as wide as in *S. goodei*, and does not exceed the extremity of the median article of the antennule; its lateral spine is very slender, and shorter than the antennule.

The very thick carpocerite, which is 4 times as long as wide in the female, only 3.5 times in the male, is the principal distinctive character of this species.

The large chela is more slender and elongated than in *S. goodei*, especially in the female; its relative dimensions are: Fingers 1; total length 3.66; height 1.28, in the male; and respectively 1; 4; and 1.1, in the female; the upper margin of the meropodite is strongly convex and presents no prominent anterior angle.

The small chela in the male has the following proportions: Fingers 1; total length 3; height 1; the carpus measures 0.42 of the length of the chela, and the meropodite is 4 times as long as wide; in the female the proportions of the chela become 1; 2.56; 0.8.

The two chelæ are notably smaller in the female (proportions 1.15 for the large; 1.1 for the small chela).

In the second pair the first segment of the carpus is smaller than the sum of the four others, and is also smaller than the terminal chela.

The proportions of the third pair are: Meropodite 2.43; carpus 1; propodite 2; the meropodite is 4.4 times longer than wide; in the female the proportions become 3; 1; 2.15; and the meropodite is more than 5 times as long as wide.

The height of the telson is 1.47 times the width of the base and 4.7 times the posterior margin; it is consequently more elongated than in *S. goodei*; the spines of its upper surface are weak, and the inner spines of the posterior border are more than twice as long as

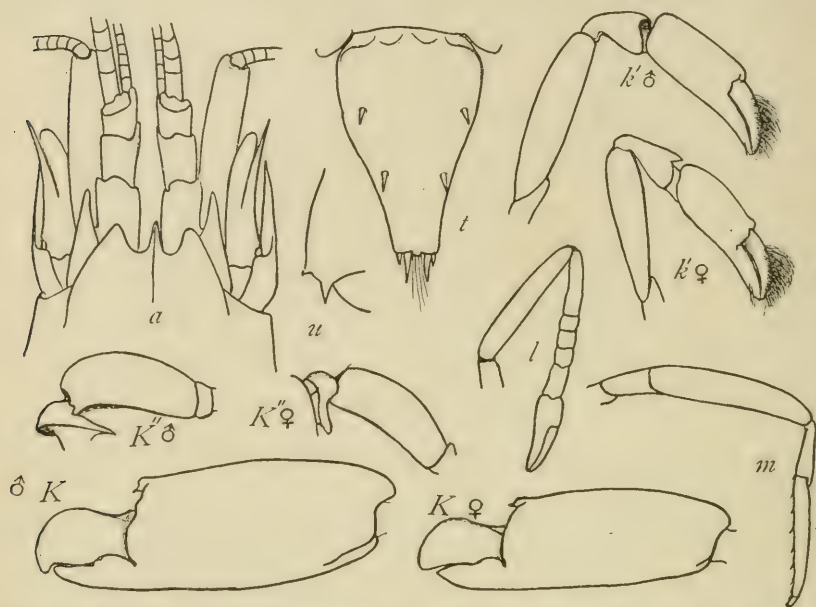


FIG. 35.—*SYNALPHEUS SANCTITHOMÆ*. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA, MALE AND FEMALE; *K''*, CARPUS AND MEROPODITE OF LARGE CHELIPED, MALE AND FEMALE; *k'*, SMALL CHELIPED OF FIRST PAIR, MALE AND FEMALE; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *t*, TELSON; *u*, UROPOD.

the outer; the border of the outer uropod has not more than 2 fixed teeth, without an intermediate sutural spine.

The eggs give rise to zoëæ (0.8 mm. in greatest diameter).

#### Localities:

St. Thomas, 20 to 23 fathoms, *Fish Hawk* Station No. 6079, 1 male and 1 female of very small size (9 mm.), types.

St. Thomas, 20 fathoms, *Fish Hawk* Station No. 6080, 1 female.

*Type*.—Cat. No. 24782, U.S.N.M.

#### *SYNALPHEUS GRAMPUSI*, new species.

The three frontal teeth are equal in length, but the rostrum, with parallel margins, is scarcely one-fourth of the width of the lateral teeth, which are widely rounded at their extremity: the intervals between the rostrum and the lateral teeth have parallel borders, and are therefore U-shaped: the rostrum is placed at a lower level, and is continued backward by a short and narrow crest.

The segments of the antennule are to one another as 2.15, 1.3, 1; the stylocerite is a little shorter than the basal article; the basicerite has its upper angle a right angle, and its lateral spine very strong, reaching the last third of the distal segment of the antennule; it has the same width and length as that of the scaphocerite, which bears no trace of a scale in either sex; the carpocerite exceeds the antennule by the length of the distal article, and is 5.5 times longer than wide, a little concave exteriorly.

The proportions of the large chela are: Fingers 1; total length 3.3; height 1.3; it is consequently much like that of *S. goodei*, and likewise possesses a strong tubercle on the anterior margin of the palm, with a short spine directed toward the base; the meropodite has a straight, not spinous, upper margin.



FIG. 36.—SYNALPHEUS GRAMPUSI. *a*, FRONTAL AND ANTENNAL REGION, MALE; *a* ♂, ANOMALOUS SPECIMEN; *K*, LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR, MALE AND FEMALE; *t*, TELSON; *u*, UROPOD.

The small chela is to the large as 1 to 2.9. Its relative dimensions are: Fingers 1; total length 2.68; height 0.85 to 0.9; both fingers end in a sharp point; the carpus is 0.52 of the entire cheliped; the meropodite is 3.9 times longer than wide.

In the female these proportions become, for the large chela: Fingers 1; total length 3.3; height 1.37; and for the small chela, respectively, 1; 2.78; 0.9; the large chela is therefore a little more thick-set in the female, and the fingers of the small claw are slightly shorter.

In the second pair the first segment of the carpus equals the terminal chela, the sum of the other 4 segments being greater; the carpus is about 9 times as long as wide.



The third pair is very robust in the male. The relative dimensions are: Meropodite 2.33; carpus 1; propodite 1.6; the meropodite is only 3 times as long as wide; the dactyl has its two hooks almost equal, the ventral a little stronger.

In the female the proportions remain the same, but the dimensions of the second and third pairs are noticeably less (about 0.8).

The height of the telson is 1.2 times the width at the base, and 3.9 to 4 times the posterior margin, the last dimension as in the males; the border bears 4 equal and almost equidistant spines, including between them, on a narrow, convex portion of the margin, 5 hairs, of which 3 are large and plumose; the spines of the upper surface are longer than those of the margin.

The outer border of the uropod bears 6 to 8 spines, the first large, continuing the border of the suture, the second and following rapidly diminishing; only the last or the last two are not mobile.

The eggs give rise to zoëæ.

I have never met with any vestige of an antennal scale; on the other hand, a male (*Fish Hawk* Station No. 7124) shows an interesting variation in the length of the antennal spines, which do not reach to the extremity of the median antennular article; this specimen indicates the way in which *S. paudionis*, the next American species described, has become differentiated.

One female (*Grampus* Station No. 5116), of which all the eggs are hatched, and the zoëæ are still present under the abdomen, shows the opposite variation; both the antennal spines equal the antennule, and are also thicker than usual; the stylocerite is also a little longer.

#### Localities:

##### Gulf of Mexico:

Lat.  $26^{\circ} 30' N.$ , long.  $83^{\circ} 30' W.$ , 33 fathoms, *Grampus* Station No. 5116, a female (not quite typical).

Lat.  $26^{\circ} 33' N.$ , long.  $83^{\circ} 10' W.$ , 28 fathoms, *Fish Hawk* Station No. 7123, 1 male, 2 females, types.

Lat.  $25^{\circ} 50' 15'' N.$ , long.  $82^{\circ} 41' 45'' W.$ , 21 fathoms, *Fish Hawk* Station No. 7124, 2 males, 3 females.

Lat.  $27^{\circ} 04' 00'' N.$ , long.  $83^{\circ} 21' 15'' W.$ , 26 fathoms, *Albatross* Station No. 2409.

*Type*.—Cat. No. 38399, U.S.N.M.

The species is very close to the one that I described in a previous paper under the name *S. la rimannus* var. *parfaiti*, and which should also be separated as a distinct species. It is unfortunately represented by a single female, of which the small chela is missing.

The frontal teeth and the rostrum are separated by wider intervals with divergent margins; the lateral teeth are wider at the base and less obtuse at the extremity; the rostrum is on a level with them, and

is prolonged backward by a very slight, but wide, crest. The articles of the antennule are to one another as 1.8, 1, 1.

The lateral spine of the basicerite is a little longer than the antennule and also than the spine of the scaphocerite; the latter is a little narrower than the preceding, and carries a very well marked rudiment of a scale which does not, however, exceed the extremity of the basal antennular article.

The large chela has as proportions, fingers 1; total length 4; height 1.5; it is more tapering distally, and the tubercle on the margin of the palm is less prominent, bearing no spine; the superior margin of the meropodite is convex, and rounded at the distal extremity.

The small chela is missing.

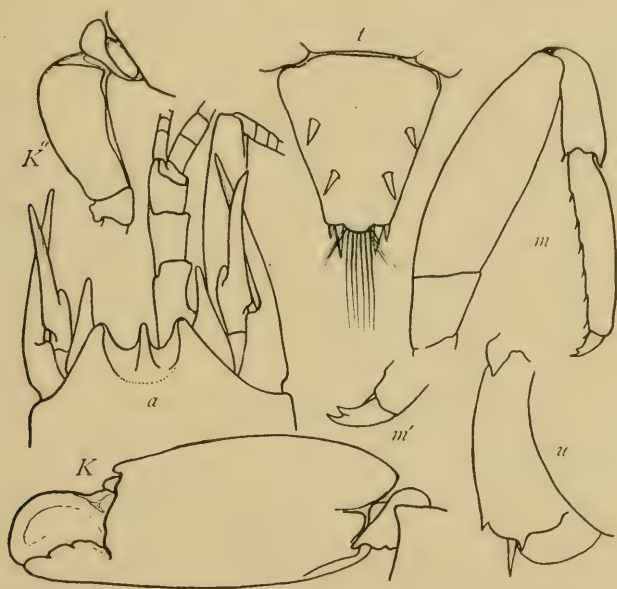


FIG. 37.—SYNALPHEUS PARVIFRONS. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA AND CARPUS; *K'*, CARPUS AND MEROPODITE OF LARGE CHELIPED; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON; *u*, UROPOD.

In the second pair the first segment of the carpus, the four following, and the distal chela are approximately equal.

The proportions of the third pair are: Meropodite 2.28; carpus 1; propodite 1.7; the meropodite is 3 times longer than wide, as in *S. grampusi*.

The height of the telson is 1.08 times the width of the base, 2.66 times the posterior margin, which latter has its inner spines 2.5 times wider than the outer, and also much stronger; between them are six plumose hairs and two lateral groups of three simple hairs; the spines of the superior face are shorter and stronger than in *S. grampusi*.

The external margin of the uropod bears only two short teeth, with one long movable spine nearer the sutural tooth.

The larvæ are zoëæ.

The type comes from Annobon, off the west coast of Africa (Count Parfaite, Paris Museum).

Named for the collector.

*Synalpheus levimanus* (Heller) of the Mediterranean is quite distinct from both of these species; the frontal margin bears three equal teeth, the rostrum being about two-thirds as wide as the lateral teeth, and in height four times its median width, or a little less.

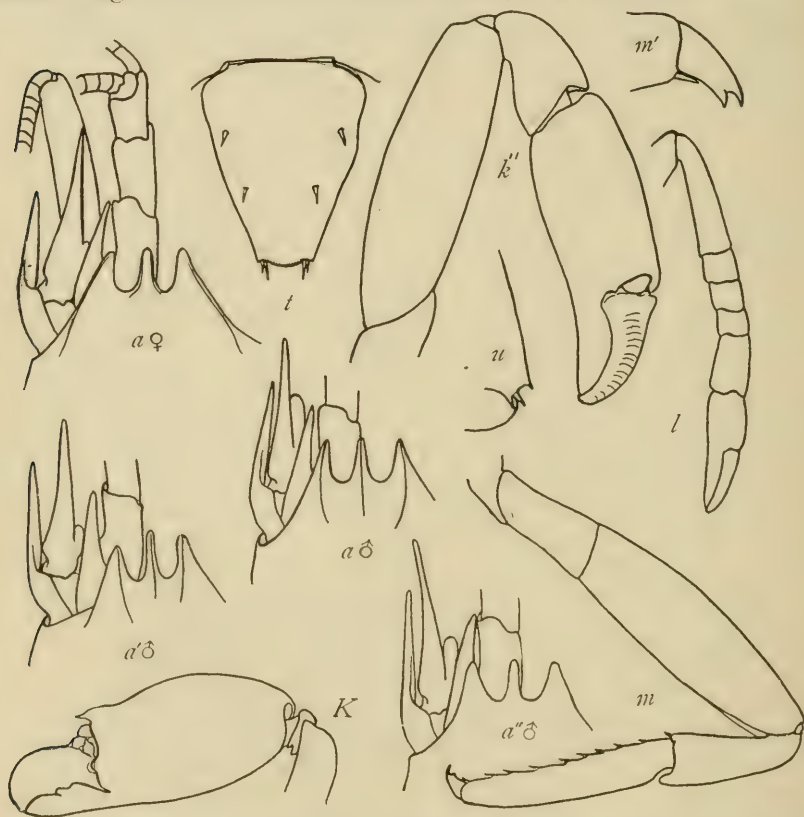


FIG. 38.—*SYNALPHEUS LEVIMANUS*. *a*, FRONTAL AND ANTENNAL REGION, MALE AND FEMALE; *a'*, FRONTAL AND ANTENNAL REGION, MALE WITH RUDIMENTARY SCALE; *a''*, FRONTAL AND ANTENNAL REGION, MALE INTERMEDIATE; *K*, LARGE CHELIPED; *k''*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON; *u*, UROPOD.

The articles of the antennule are to one another as 1.57, 1.07, 1; the stylocerite is narrow and equals the basal article.

The superior angle of the basicerite is obtuse, its lateral spine reaching to at least the middle of the basal antennular article; the scaphocerite is not provided with a scale in the females, where its place is only indicated by a slight prominence of the inner margin of the spine; in the males the scale is of variable length, from a very slight

rudiment to a scale reaching the proximal third of the median antennular article; its lateral spine, wider than that of the basicerite, hardly reaches beyond the middle of the distal antennular article; the carpocerite exceeds the antennule by one-half of the distal article, and is 6 times longer than wide.

The proportions of the large chela, in the male, are: Fingers 1; total length 3.4; height 1.35; the anterior margin of the palm bears a tubercle which terminates in a horizontal spine; the meropodite is rounded and unarmed on its superior margin; the proportions are the same in the female, but the palm is more tapering anteriorly.

The proportions of the small chela are: Fingers 1; total length 2.8; height 1; the carpus measures only 0.35 of the entire chela; the meropodite is 3.3 times as long as wide; the fingers terminate in a single point; the plume of hairs of the movable finger is less thick than in *S. grampusi*. In the female the small chela is only slightly narrower, the proportions being 1, 2.8, 0.92; the meropodite, with the same proportions, is also a little more slender.

In the second pair, in both sexes, the first segment of the carpus, the sum of the four following ones, and the distal chela, are nearly equal, but progressively diminish slightly in length; the carpus is 10 times longer than wide.

The proportions of the third pair are: Meropodite 2; carpus 1; propodite 1.6; the meropodite is 3.5 times longer than wide; the dactyl is short, terminating in two equal and slightly divergent hooks.

In the female the proportions are approximately the same; the height of the telson is 1.25 times its base and 3.6 times its posterior margin, which bears two pairs of feeble spines, the inner ones slightly the longer; between these are ten plumose hairs.

The external uropod bears only two feeble teeth, with a movable spine between them.

The eggs give rise to zoëæ.

#### SYNALPHEUS PANDIONIS, new species.

This species is distinguished from *S. grampusi* only by very slight differences, of which the principal one is the presence of a well-developed antennal scale. It is also very like *S. parfaiti*, which it approaches especially in this last character. However, I believe that these three forms are perfectly distinct. They appear to be the result of different types of variation.

The frontal teeth resemble those of *S. parfaiti*, but this is not true of the stylocerite, which is always markedly shorter than the distal article of the antennule, as in *S. grampusi*: the superior angle of the basicerite is obtuse, its lateral spine reaching the extremity of the median antennular article; the scaphocerite has in both sexes a very distinct scale, which reaches the middle of the median anten-



nular article, and is sometimes as wide as the lateral spine; the latter is equal to that of the basicerite, or is very slightly shorter; the carpocerite exceeds the antennule by  $1\frac{1}{2}$  times the length of the distal article; it is concave exteriorly and 6.5 times longer than wide, being, in consequence, more slender than in *S. grampusi* and *S. parvifiti*.

The proportions of the large chela are: Fingers 1: total length 3.3; height 1.3 in the male; that of the female is more stocky, the last dimension reaching 1.4; T. L.: H.=2.3:2.5. By its form, by the spine, which is directed obliquely downward, and is on the anterior border of the palm, this chela is much like that of *S. grampusi*.

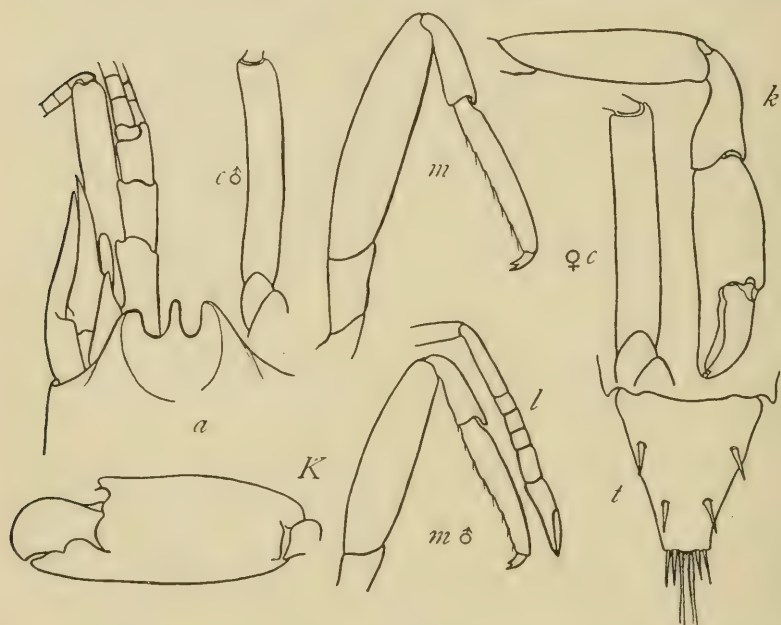


FIG. 39.—SYNALPHEUS PANDIONIS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE, MALE AND FEMALE; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR, MALE AND FEMALE; *t*, TELSON.

The small chela is to the large as 1 to 3, in both sexes; it is consequently smaller than in specimens of *S. grampusi* of the same size; the proportions are as follows: Fingers 1: total length 2.4; height 0.72; it is therefore more slender than in *S. grampusi*.

The second pair has the same proportions as in *S. grampusi*, but it is a little more slender (proportion about 1:1.08) especially in the female.

The third pair are similar: the meropodites are equal in two specimens, one of *S. grampusi* and one of *S. pandionis*, of the same length, but the proportion of the length to the width is 3.3 in the first case, 3.8 in the second, even more pronounced in the male; in the female of *S. pandionis* this proportion is reduced to 3.7.

The telson is like that of *S. grampusi*; the outer uropod bears 4 to 6 spines.

The eggs give rise to zoëæ.

Locality: St. Thomas, 20 to 23 fathoms, *Fish Hawk* Station No. 6079; 2 males, 4 females.

Among the specimens is a female which may be considered an "*oxyceros*" form (subspecies *extentus*) of this species, as the spines of the basicerite and of the scaphocerite equal the antennule, and the antennal scale reaches the end of the median antennular article. *S. grampusi* and *S. parfaiti* are equally "*oxyceros*" relative to *S. pandionis*, which last may be considered as more primitive and less adapted to creeping or fixed life on account of the persistent antennal scale, the more feeble feet, the less armed uropods, etc.

Type of *S. pandionis*.—Cat. No. 38400, U.S.N.M.

Type of *S. pandionis extentus*.—Cat. No. 38401, U.S.N.M.

**SYNALPHEUS BROOKSI, new species.**

This species and those following (*S. tanneri*, *S. herricki*, and *S. pectiniger*) constitute in the LÆVIMANUS group a collection of forms closely allied, of small size and often associated. In the absence of the small cheliped it is a difficult matter to separate *S. brooksi* and *S. pectiniger*, as they both show curious anomalies in the number and size of the eggs; after *S. longicarpus* (in company with which they are frequently found), they are among the most common forms.

*S. brooksi* has the tridentate portion of the frontal border distinct, joined to the adjacent portions by slightly concave curves; the three frontal teeth are short and equal, the rostrum narrower; the axes of the lateral teeth are divergent.

The articles of the antennule are to each other as 1.7, 1.05, 1; the stylocerite, short and wide, reaches about the middle of the basal article; the superior angle of the basicerite is very obtuse, its lateral spine reaching the middle of the median antennular article; the scaphocerite is absolutely devoid of a scale and is reduced to its lateral spine, which is more slender and very slightly longer than the preceding; the cylindrical carpoperite, a little concave externally, exceeds the antennule by three-fourths of the distal article; it is



FIG. 40.—SYNALPHEUS PANDIONIS EXTENTUS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE.

short, only 4.5 times longer than wide (4.4 in the male, 4.6 in the female).

The sexes frequently differ in the proportionate size of the large chela, but this character is very inconstant. The most massive form, which I have observed in the males, correspond to the follow-

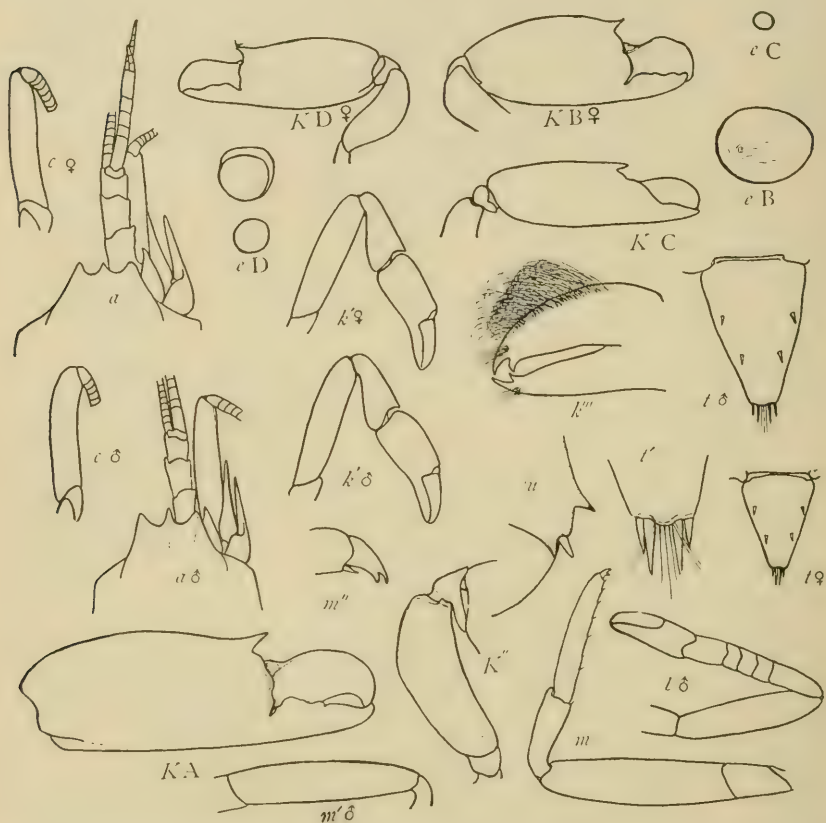


FIG. 41.—*SYNALPHEUS BROOKSI*. *a*, FRONTAL AND ANTENNAL REGION, MALE AND FEMALE; *c*, CARPOCERITE, MALE AND FEMALE; *e B*, EGG OF NORMAL SIZE; *e C*, EGG OF ABNORMAL SIZE FROM FEMALE, ALBATROSS STATION NO. 2362; *e D*, EGGS OF ABNORMAL SIZE FROM FEMALE, BLAKE; *K A*, LARGE CHELA, FEMALE, BLAKE; *K B*, LARGE CHELA, FEMALE, BLAKE; *K C*, LARGE CHELA, ANOMALOUS, ALBATROSS STATION NO. 2362; *K D*, LARGE CHELA, ANOMALOUS, FEMALE, BLAKE; *K'*, CARPUS AND MEROPODITE OF LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR, MALE AND FEMALE; *k''*, FINGERS OF SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, MEROPODITE OF THIRD PAIR; *m''*, DACTYL OF THIRD PAIR; *t*, TELSON, MALE AND FEMALE; *t'*, EXTREMITY OF TELSON; *u*, UROPOD.

ing dimensions: Fingers 1; total length 3.43; height 1.26 (*Albatross* Station No. 2362), the proportion of the length to the height being only 2.7; but it is much more frequent to find the chela becoming more slender and this proportion equal to 2.9, 2.97, 3; the

extreme cases are those in which the proportion becomes equal to 3.25, the fingers being equal in length to the height of the palm.

In the female there are some very similar variations. I have found in a very ovigerous female (all the eggs of which were of normal volume) these proportions: Fingers 1; total length 3.6; height 1.28; the proportion L.: H. being 2.8; it is a chela which one would not know how to differentiate from that of a male, any more by its absolute dimensions than by its size in relation to that of the animal. The extreme cases are those in which the proportions become: Fingers 1; total length 2.75; height 0.9; the proportion of L.: H. then being about 3.05, and the fingers very elongate; I have met with this last form particularly among some anomalous females, carrying few eggs, very small, and probably sterile.

The most typical specimens, among those which appear to me to have been collected together, have their large chelæ very dissimilar: as an example, the proportions of a male and a female of the same size from Curacao are given below:

	Cephalo- thorax.	Large chela (total length).	Proportion L. H.	Proportion H. D.	Proportion of the large chela to the cephalo- thorax.
Male (12 mm. long) ..	5.0	} Proportion 1.5 {	3.00	1.17	1.24
Female (12 mm. long)	4.6		3.29	1.05	.88

It is seen here that the male and female, as is very frequently the case in the Synalpheids, differ in the length of the abdomen, which is longer and especially stouter in the female, where the eggs distend the pleura, and also in the large chela, which is smaller and more slender in the female.

A constant character of the large chela is the presence of a conical tubercle, very prominent, and directed a little obliquely upward, which terminates the anterior border.

The small chela in the male is to the large in the proportion of 3.3 to 3.4; its relative proportions are: Fingers 1; total length 2.7 to 2.8; height 0.9 to 0.95; the fingers each terminate in two hooks; the carpus measures 0.46 to 0.5 to 0.51 of the whole chela; the meropodite is 3.6 times as long as wide.

In a female chosen from among the most normal specimens the small chela is to the large one in the proportion of about 2.3; its relative proportions are approximately the same as in the male, the carpus being, however, longer (0.5 to 0.6 of the total chela).

In the second pair the proportions of the first segment of the carpus, of the four following ones, and of the chela are 1, 1.2, 1.2; the meropodite measures 0.9 of the carpus in the female; in the male these proportions become 1, 1.4, 1.4, and the meropodite is equal to the carpus.



In the third pair the proportions are: Meropodite 2.26; carpus 1; propodite 1.62; the meropodite is no thicker in the male than in the female (proportions 4.3 to 4.5); the dactyl is short, with two teeth slightly divergent, the ventral a little stronger and shorter.



FIG. 42.—SYNALPHEUS BROOKSI STREPSICEROS. *a*, FRONTAL AND ANTENNAL REGION; *c*, CARPOCERITE; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR.

The height of the telson in the males is a little less than 4 times its posterior margin and 1.23 times its wide base; in the females this last proportion becomes 1.1; between the posterior spines, the inner of which are the longer, are found four plumose hairs, with two pairs of simple divergent hairs; the outer uropod bears only two teeth, between which is a movable spine.

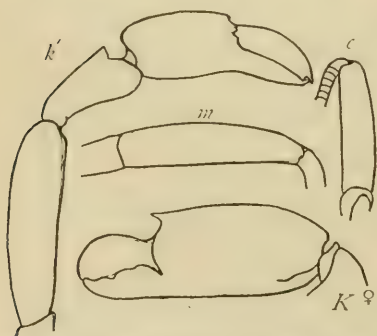


FIG. 43.—SYNALPHEUS BROOKSI ELEUTHERE. *c*, CARPOCERITE; *K'*, LARGE CHELA, FEMALE; *k'*, SMALL CHELIPED; *m*, MEROPODITE OF THIRD PAIR.

The eggs are very large; I have counted at the most sixteen, and they give rise to very advanced mysis larvæ. When freshly laid they measure about 1.1 mm. in the long axis, and they increase to 1.6 mm. when the sixth pleosomite attains the height of the eyes in the larva folded in the egg; but females are also frequently found whose eggs do not exceed 0.5 to 0.6 mm. in the long axis; these eggs are, moreover, few (3 to 10) and have a chalky aspect in alcohol; they are

probably not destined to develop. These females have in their abdominal pleura the characters of the males, as if they had been castrated by some internal parasite.

Named for the late Prof. William K. Brooks, of Johns Hopkins University.

The species presents some interesting variations. One male from St. Thomas differs from the types in certain points: (1) The spines of the scaphocerite and basicerite are longer; (2) the carpopodite is

slender, 5.5 times longer than wide; (3) the fingers of the small chela are elongated, the proportions being: Fingers 1; total length 2.38; height 0.76; proportion L.: H. = 3.12:1; the carpus is 0.5 of the total length; the large chela is absent; the second and third pairs have their usual characters.

This specimen may be distinguished under the name of *S. brooksi strepsiceros*.

The elongation of the carpocerite in this specimen is a variation in the direction of the species *herricki*.

A second variation, bearing this time on the small chela, characterizes some specimens from the Bahamas (3 females, 5 males); the carpocerite remains short (proportion 4, 4.1), thicker even than in typical *S. brooksi*; the spines of the scaphocerite and of the carpocerite, especially of the latter, are stronger and longer than in the types; the large chela is similar in the two sexes, and even slightly thicker in the females; the proportions are those of the extreme cases met in *S. brooksi*.

	Fingers.	Total length.	Height.	Sex.	L.: H.
Form <i>eleutherae</i> .....	1	3.0	1.17	Female...	2.65
Do.....	1	3.2	1.14	Male .....	2.8
<i>S. brooksi</i> , extreme.....	1	3.43	1.26	...do.....	2.7
Do.....	1	3.6	1.28	Female...	2.8

The palm is thus shorter, while remaining as broad, in this character approaching *S. herricki*; the proportions of the small chela are: Female, fingers 1; total length 2.45; height 0.85; carpus 0.53 of the total length; male, fingers 1; total length 2.5; height 1; carpus 0.57 of the total length; the meropodite is 3.85 times as long as wide in the females, 3.8 times in the males. The males thus seem to show particularly the tendency to the lengthening of the carpus which characterizes *S. herricki*, but this lengthening is almost as marked in the females, where it is hidden by the elongation of the chela and especially of the fingers; the feet of the second and third pairs are those of *S. brooksi*.

These specimens may be named *S. brooksi eleutherae*.

Localities:

Bahamas:

B. A. Bean, 1 specimen.

Andros Island, 1 specimen.

The Current, Eleuthera Island, B. A. Bean, 8 specimens, form *eleutherae*, type, Cat. No. 38403, U.S.N.M.

Florida:

Harbor Key, Union University collection, 1 specimen.

Salt Pond Key, Edward Palmer, about 50 specimens.

## Localities—Continued:

## Florida—Continued:

Sugar Loaf Key, 50 males and females (several anomalous), including types.

Key West, H. Hemphill, 2 specimens.

Gulf of Mexico, 27 fathoms, *Albatross* Station No. 2372, 40 males and females.

Yucatan, off Cape Catoche, 25 fathoms, *Albatross* Station No. 2362, 80 males and females.

Vieques, 14 fathoms, *Fish Hawk* Station No. 6085, 1 specimen.

Vieques, 12½ fathoms, *Fish Hawk* Station No. 6095, 2 specimens.

St. Thomas, 20 to 23 fathoms, *Fish Hawk* Station No. 6079, 2 specimens.

St. Thomas, 1 specimen, form *strepsiceros*, type, Cat. No. 8936, U.S.N.M.

Brazil, off Cape St. Roque, 20 fathoms, *Albatross* Station No. 2758, 1 specimen.

Type of *S. brooksi*.—Cat. No. 38402, U. S. N. M.

## SYNALPHEUS HERRICKI, new species.

The tridentate portion is distinct from the rest of the frontal margin, to which it is united by rectilinear borders; the three teeth are approximately equal in length, the rostrum a little narrower than the lateral teeth, which are at least as long as wide at the base, and usually longer.

The articles of the antennule are as 2, 1.4, 1; the stylocerite reaches the distal third of the basal article.

The superior angle of the basicerite is obtuse; its lateral spine reaches to at least the middle of the median antennular article; it is 1.5 times thicker than the spine of the scaphocerite, which bears no trace of a scale; it is usually, also, very slightly longer, but it may be only equal to it; the two spines are straight and parallel.

The large carpocerite exceeds the antennule by the length of the distal article; it is a little concave, cylindrical, 5 times as long as wide in the males, or 4.7 to 4.8 in the females.

The proportions of the large chela are very similar in the two sexes: Fingers 1; total length 3.25 to 3.4; height 1.33 to 1.35; the ratio is L.:H.=2.42 to 2.5:1; these figures apply to the males; in the females they become, respectively, 1, 3 to 3.2, 1.2 to 1.35, 2.3 to 2.5; the large chela in the female is generally proportionately broader, with the fingers a little longer: the superior margin of the meropodite is convex and unarmed; it is 2.2 times longer than wide.

In the male the proportions of the small chela are: Fingers 1; total length 2.8; height 1; the carpus is always longer than the palm, measuring 0.8 of the whole chela; the meropodite is 3.3 times longer

than wide; it is thicker than the chela (proportion 1.23), and almost as long as the carpus and the chela joined (proportion 0.79).

In the female the proportions become 1, 2.45, 0.87, the fingers being longer; the carpus measures no more than 0.67 of the whole chela; the meropodite is 3 times longer than wide, and is also thicker than the chela; it measures 0.74 of the carpus and the chela together; the size being the same, the sexual differences in the length of the chela

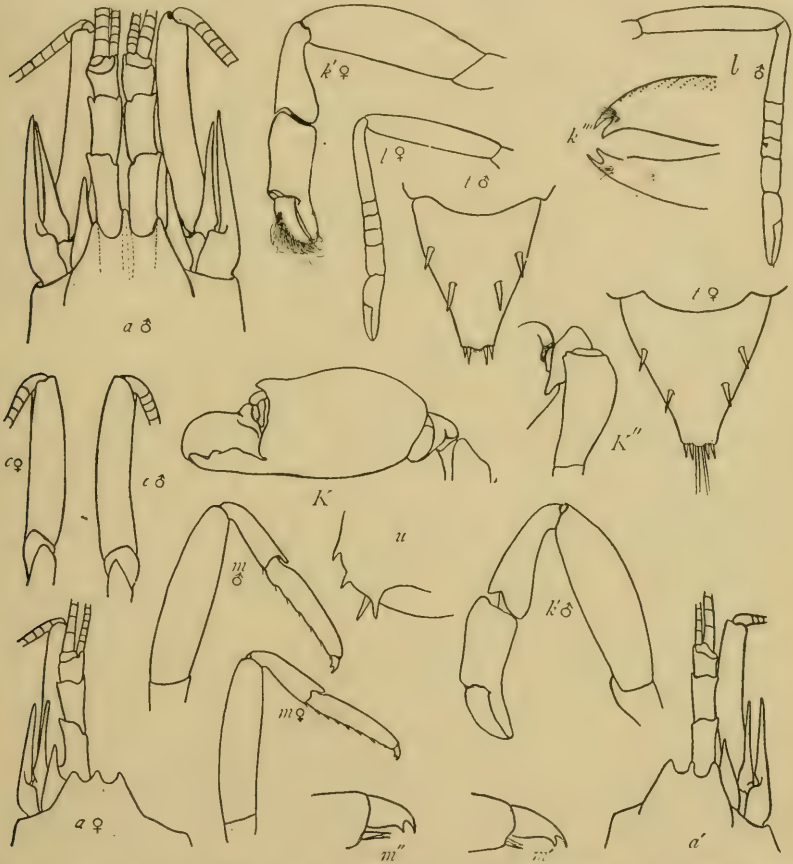


FIG. 44.—SYNALPHEUS HERRICKI. *a*, FRONTAL AND ANTENNAL REGION, MALE AND FEMALE; *a'*, FRONTAL AND ANTENNAL REGION OF ANOTHER MALE; *c*, CARPOCERITE, MALE AND FEMALE; *K*, LARGE CHELA; *K''*, CARPUS AND MEROPODITE OF LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR, MALE AND FEMALE; *l*, FOOT OF SECOND PAIR, MALE AND FEMALE; *m*, FOOT OF THIRD PAIR, MALE AND FEMALE; *m'*, DACTYL OF THIRD PAIR OF TYPICAL MALE; *m''*, DACTYL OF THIRD PAIR OF ANOTHER MALE; *t*, TELSON, MALE AND FEMALE; *u*, UROPOD.

are expressed by the proportions 1.45 for the large, 1.15 for the small chela.

In the second pair the first segment of the carpus is, in the male, a little shorter than the sum of the four others, in the female a little longer; the meropodite is a little longer in the male, the whole member being more elongated (proportion 1.2).



In the third pair the proportions are: Meropodite 2.5; carpus 1; propodite 1.55 (male); and 2.25, 1, 1.4 (female), by the shortening of the meropodite and the propodite. In both cases the meropodite is about 4 times as long as wide; the dactyl is small, tapering distally, with two slightly divergent hooks, the ventral the stronger and a little the shorter.

The height of the telson in the male is 1.6 times its base, 3.7 times its posterior margin; in the female the height equals the base, and is 4.5 times the posterior margin; in both cases the spines of the superior face are very strong, and are larger than the inner spines of the posterior margin; between the latter are four plumose hairs and two groups of four simple divergent hairs; the external uropod generally bears four teeth on its free margin, and in addition a movable spine;

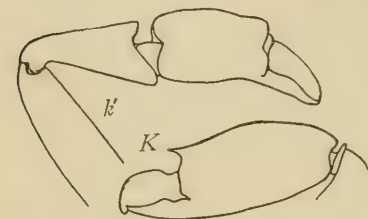


FIG. 45.—SYNALPHEUS HERRICKI ANGUSTIPES. K, LARGE CHELA; K', SMALL CHELIPED OF FIRST PAIR.

in the males the teeth may be three or two in number.

The eggs are of large size and give rise to mysis larvæ.

Named for Dr. Francis H. Herrick, of Adelbert College.

This species, like the preceding, shows several variations. Among the very typical specimens from *Fish Hawk Station* No. 7106 I find a female whose small chela is aberrant. In the females of *S. herricki* the meropodite and the sum of the carpus and the chela are in the proportion of 0.74; in the specimen cited this portion is 0.71, and the meropodite is more slender; the width is not, in fact, greater than that of the palm, which latter is less swollen at the base, its margins being parallel along its whole length, the proportions being T. L.: H.=3 instead of 2.6 to 2.8; the carpus is no more than 0.65 of the entire chela, and it is as wide as the palm at its distal end. In all its other characters this female (form *angustipes*) is a true *herricki*; in its small chela it approaches *S. brooksi*.

Six females from the same station show some differences in the same direction, but still more accentuated and not exactly comparable. The palm and carpus of the small cheliped are very typical, the latter measuring nearly 0.8 of the total chela, as in the male of *S. herricki*, and the palm being swollen at its base; the meropodite measures 0.77 of the carpus and chela together, which is also a character of the male of *S. herricki* (proportion 0.79), but it is 4 times as long as wide (in-

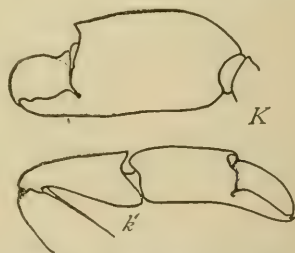


FIG. 46.—SYNALPHEUS HERRICKI DIMIDIATUS. K, LARGE CHELA; K', SMALL CHELIPED OF FIRST PAIR.

stead of 3.3 in the male, or 3 in the female) and its width is only 0.78 of that of the palm (instead of 1.23 in the male, 1.15 in the female, of *S. herricki*). This slenderness of the meropodite recalls *S. brooksi*. On the other hand, the large chela is equally slender, as in that last species: Fingers 1; total length 3.28; height 1.22; proportion T. L.: H. = 2.7 (1, 3.6, 1.28, 2.8 in the female of *S. brooksi*, in which the large chela resembles more that of the male). The anterior palmar tubercle also ends in a slender point.

I shall give to these last specimens the name of *S. herricki dimidiatus*.

Another variation is presented by a female from Albatross Station No. 2372. The rostrum is narrower and the lateral spines wider and more obtuse than in *S. herricki*. The proportions of the large chela

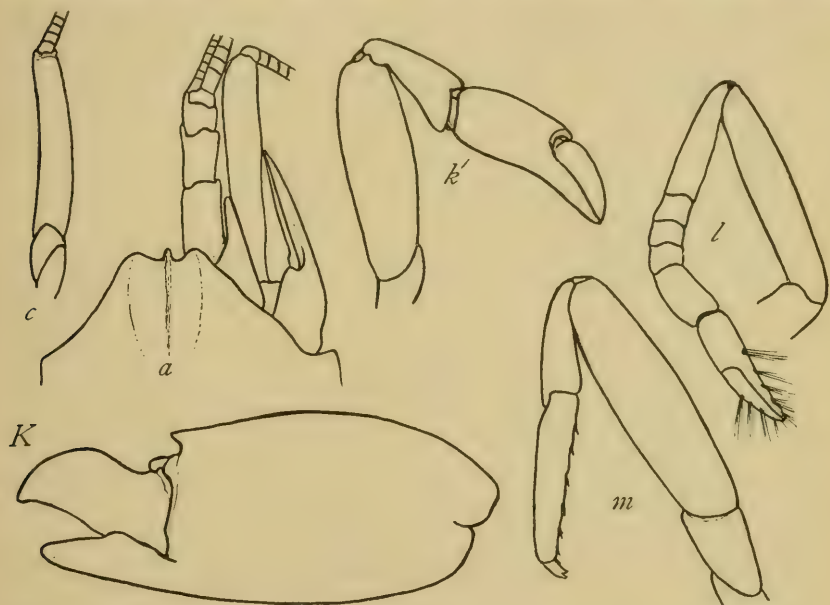


FIG. 47.—SYNALPHEUS TANNERI. a. FRONTAL AND ANTENNAL REGION; c, CARPOCERITE; K, LARGE CHELA; k', SMALL CHELIPED OF FIRST PAIR; l, FOOT OF SECOND PAIR; m, FOOT OF THIRD PAIR.

are: Fingers 1; total length 3.35; height 1.39; proportion T. L.: H. = 2.4, which approaches near to *S. herricki*; the anterior palmar tubercle is very obtuse; the small chela differs from that of *S. herricki* in the short carpus, measuring only 0.56 of the whole chela: the cheliped is also more slender, the width of the meropodite being 1.2 times its ordinary width; in spite of the shortness of the carpus, the meropodite measures 0.75 of the carpus and chela together, as in the female of *herricki*, the palm of the small chela being more elongate than in the types of the species (fingers 1, total length 2.6, height 0.8, ratio T. L.: H. = 3.2, instead of 1, 2.47, 0.87, 2.8 in *S. herricki* female); the feet of the second pair, rather slender in *S. herricki*,

are here very stout; compared with two specimens of almost equal size (17 mm. for *S. herricki* female; 15.5 mm. for *S. tanneri* female type), these appendages are in the ratio of 0.8 in total length and thickness; the proportion of the segments of the carpus is no longer the same, the first segment being here shorter than the sum of the four others, as in the female of *herricki*; the feet of the third pair are also stouter than in *S. herricki*, the proportions of these members being about 0.8; the relative lengths of the several segments are the same as in *S. herricki* male; there are also some differences in the dimensions of the carpocerite (ratio 5.43 instead of 4.8 in *S. herricki* female and 5 in *S. herricki* male), this being more slender than in the types, and there again approaching some proportions observed in the male.

Although unique, this specimen ought, I believe, to constitute the type of a distinct species, for which I propose the name *S. tanneri*, in honor of the late Z. L. Tanner, formerly commander of the *Albatross*.

Localities (for *S. herricki* and allies):

Anclote, Florida; Capt. Thomas Low; about 150 specimens (types of *S. herricki*).

Gulf of Mexico, lat.  $25^{\circ} 50' 15''$  N., long.  $82^{\circ} 41' 45''$  W., 21 fathoms, *Fish Hawk* Station No. 7124, 1 specimen (*S. herricki*).

Anclote Section, Florida,  $12\frac{1}{2}$  fathoms, *Fish Hawk* Station No. 7106, about 30 specimens (*S. herricki*).

Anclote Section, Florida,  $12\frac{1}{2}$  fathoms, *Fish Hawk* Station No. 7106, 6 specimens (type of form *dimidiatus*).

Anclote Section, Florida,  $12\frac{1}{2}$  fathoms, *Fish Hawk* Station No. 7106, 1 specimen (type of form *angustipes*).

Gulf of Mexico, lat.  $29^{\circ} 15' 30''$  N., long.  $85^{\circ} 29' 30''$  W., 27 fathoms, *Albatross* Station No. 2372, 1 specimen (type of *S. tanneri*).

Type of *S. herricki*.—Cat. No. 38404, U.S.N.M.

Type of *S. herricki dimidiatus*.—Cat. No. 38405, U.S.N.M.

Type of *S. herricki angustipes*.—Cat. No. 38406, U.S.N.M.

Type of *S. tanneri*.—Cat. No. 38407, U.S.N.M.

SYNALPHEUS PECTINIGER, new species.

While recalling the preceding species by its small size and very large eggs, this form is also closely allied to *S. longicarpus* Herrick, and may easily be confounded with small specimens of that species.

The frontal margin has three wide teeth, the median narrower in its distal half and a little longer than the lateral, but the width of the intervals separating them is always greater than their depth.

The proportions of the antennular articles are 2, 1.15, 1; the flagella are stout, the external one bifurcated after the fifth article. The stylocerite is usually a little shorter than the basal article, though often equaling it, especially in the females.

The superior angle of the basicerite is a right angle, its outer spine very strong, a little shorter than the first two articles of the anten-



FIG. 48.—SYNALPHEUS PECTINIGER. *a*, ANTERIOR HALF, FEMALE; *a'*, FRONTAL AND ANTENNAL REGION, MALE; *K*, LARGE CHELIPED; *k*, SMALL CHELIPED OF FIRST PAIR, MALE AND FEMALE; *k''*, FINGERS OF SMALL CHELIPED OF FIRST PAIR; *k'k''*, REVERSE OF SAME; *l*, FOOT OF SECOND PAIR, MALE AND FEMALE; *m*, FOOT OF THIRD PAIR, MALE AND FEMALE; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON, MALE AND FEMALE.

nule. The scaphocerite is absolutely without scale in both sexes; the lateral spine which alone represents it has a concave inner margin, and does not even present at its base a convex prominence marking the place of the absent scale; this spine, at least in its distal half, is more slender than that of the basicerite, in contrast to *S. longi-*



*carpus*; it is also shorter than the antennule, especially in the females, while in *S. longicarpus* it is always longer.

The carpocerite surpasses the antennule by two-thirds or only one-half of the distal article: it is cylindrical, a little concave on the outside, and 6.8 times as long as wide.

In the males the proportions of the large chela are: Movable finger 1; total length 3.5; height 1.2. The anterior margin of the palm bears a strong, sharp-pointed, conical prominence directed obliquely upward. The movable finger is out of the perpendicular for at least half of its length, the inferior margin of the palm rising abruptly in the place of the fixed finger, which is unprovided with any point and serves only to receive in its cavity the inferior processes of the opposing finger.

In the females, with the same general form, the large chela is much more slender, its proportions becoming: Movable finger 1; total length 5; height 1.3. The superior margin of the meropodite is a little convex, terminating in a right angle.

The proportion of the large chelæ in the two sexes is about 1:1.7.

In the male the proportions of the small chela are: Fingers 1; total length 2.58; height 0.88. The carpus measures 0.62 of the total length. The meropodite is 3.8 times longer than wide.

In the female the proportions become 1, 3.2, 1.1, the fingers being shorter. The carpus measures only 0.56 of the total length, and the meropodite is 3.3 times longer than wide. The proportion of the small chelæ in the two sexes is hardly 1:1.06.

This appendage is quite characteristic of the species: In both sexes each of the fingers is terminated by a plate divided into three curved and obtuse teeth; on the movable finger, which appears truncated, the teeth are equal and more and more inclined downward; on the fixed finger the innermost tooth is reduced to an obtuse prominence. As the teeth cross each other when the chela is closed, they constitute an effective implement for dividing the prey.

The proportions of the second pair are: First segment of the carpus 1; sum of the four following 1.3; chela 1.15. The proportions are the same in the two sexes, the entire member being more robust in the female. The meropodite measures 0.9 of the carpus.

The proportions of the third pair are: Meropodite 2.5; carpus 1; propodite 1.64. The meropodite is 4.3 times longer than wide. In the female these proportions become 2.2, 1, 1.5, and the meropodite is a little less thick (4.1). The dactyl has two hooks directed in the same plane as the inferior border, at least in the case of the dorsal hook, which is longer and stronger than the ventral.

All the abdominal pleura, in the male, terminate in a strong triangular point: even the second and the sixth pleosomite are prolonged in two strong spines on both sides of the base of the telson.

The height of the telson, in the male, is 1.24 times its base and 5 times its posterior margin; in the female, the height hardly exceeds the base, and is 3.7 times the posterior margin. In the female, the spines of the superior face are situated on the proximal third; in the male, on the proximal half. Between the inner spines of the posterior margin, which are twice as long as the outer spines, there are three plumose hairs.

The external uropod bears two teeth on its margin, and near the inner tooth a movable spine which is longer in the female. The basal spine of the uropod is strong and curved.

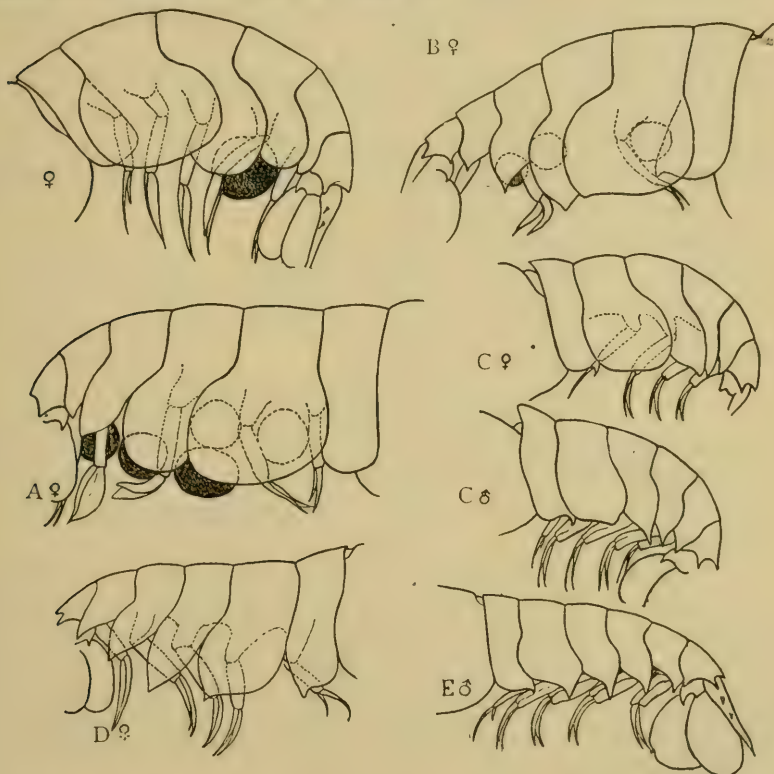


FIG. 49.—SYNALPHEUS PECTINIGER, ABDOMEN. ♀ NORMAL; A ♀, B ♀, C ♀, D ♀, DIFFERENT DEGREES OF VARIATION IN THE FORM OF THE PLEURA; C ♂, NORMAL; E ♂, ABNORMAL.

The eggs are very large and give rise to mysis larvæ. I have mentioned above that this species at an overstocked station (*Albatross* Station No. 2413, 320 males, 230 females) presents a considerable excess of males with a marked sterility of the females, as if the latter were more or less completely castrated. All the females have the fourth and fifth abdominal pleura ending in a sharp point, as in the males; all, save two have the first pleuron spinous; in the very great majority of the females, even when ovigerous, the second and third

pleura also have an obtuse point. In some cases the sex is difficult to determine, as all the pleura are strongly spinous; one can arrive at it, however, to a very great degree of approximation, by noting that the third pleuron in the males is abruptly terminated in a long point, while in the female specimens, even those most doubtful as to sex, this point is wide and arched.

The species appears very homogeneous and I have not been able to separate any variety from the typical specimens.

Localities:

Gulf of Mexico, lat.  $26^{\circ}$  N., long.  $82^{\circ} 57' 30''$  W., 24 fathoms,

*Albatross* Station No. 2413, 320 males, 230 females (with *S. longicarpus*).

Gulf of Mexico, lat.  $25^{\circ} 04' 30''$  N., long.  $82^{\circ} 59' 15''$  W., 26 fathoms, *Albatross* Station No. 2414, 1 specimen.

Florida, Sugar Loaf Key, 4 specimens.

Bahamas, Eleuthera Island, 2 specimens, male and female (largest seen, 12 and 13 mm).

St. Thomas, West Indies, 2 specimens.

Curaçao, *Albatross*, 126 males, 167 females, types.

Curaçao, *Albatross*, 2 specimens (Cat. No. 7595).

*Type*.—Cat. No. 38408, U.S.N.M.

SYNALPHEUS ANDROSI, new species.

This species is represented by a single female. The frontal margin bears 3 equal, obtuse teeth, the rostrum a little less thick than the lateral teeth; the tridentate region is distinct from the rest of the frontal border.

Antennular articles as 1.7, 1.15, 1. Stylocerite wide, shorter than the basal article. Superior angle of the basicerite straight, lateral spine reaching the middle of the median antennular article. The scaphocerite is reduced to its lateral spine, which is as long as the antennule, and a little wider than the spine of the basicerite. The carpocerite surpasses the antennule by more than the length of the distal article, and is 7 times as long as wide.

The proportions of the large chela are: Fingers 1; total length 3.4; height 1.4; it is regularly ovoid and the anterior palmar border bears only a weak conical prominence. The meropodite is unarmed on its superior border.

The small chela measures: Fingers 1; total length 2.56; height 1.2; it is consequently short and thick. The movable finger is terminated by only one sharp point; it is strongly curved, stout at its base, and bears an obtuse tubercle at the middle of its lower margin. The carpus measures 0.47 of the whole chela; it is less thick than the palm, both measured at the distal extremity (0.73). The small claw and the large one have nearly the ratio of 1 to 2.



In the second pair the first segment of the carpus, the sum of the four following, and the distal chela are apparently of the same length.

The third pair is very characteristic of the species. Like the small chela of *S. pectiniger*, its form is, so far as known, unique in the genus *Synalpheus*. Its proportions are: Meropodite 1.75; carpus 1; propodite 0.92. The meropodite is 3 times as long as wide; its ventral border is widened in the distal half into a flattened surface, which is a little excavated, and margined on the outer side by a transparent wing, on the inner side by a crest much less visible, but bearing some short, strong hairs.

The very elongate carpus, also flattened on the ventral side, is likewise bordered by an outer wing larger than that of the meropodite and capable of concealing it. On the inner side, the crest which borders it bears 5 teeth and some hairs. The propodite itself has upon nearly all its length a crest which seems to be determined by the pressure of that article against the lower border of the meropodite

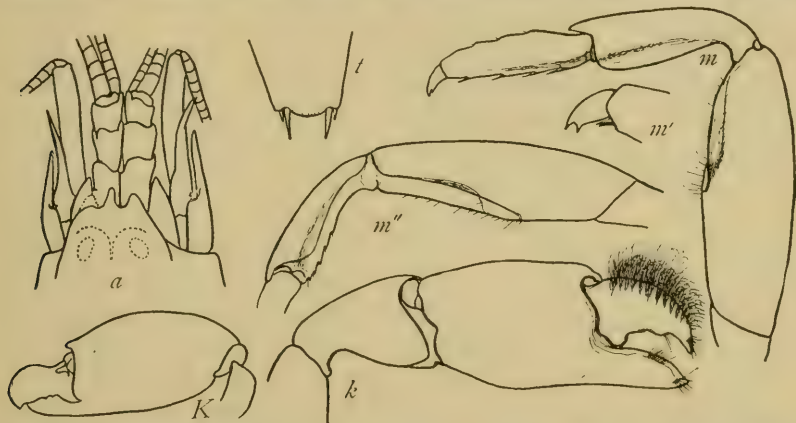


FIG. 50.—*SYNALPHEUS ANDROSI*. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *k*, SMALL CHELIPED OF FIRST PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *m''*, CARPUS AND MEROPODITE OF THIRD PAIR; *t*, TELSON.

when the leg is fully bent. In this position—which explains why the form of the carpus is more curved than is customary near its articulation—the distal end of this article is applied against a short non-excavate portion of the flattened meral surface, so that between it and the surface of the carpus there exists an interval closed outwardly by the two transparent superimposed plates. There exists in some species of *Alpheus* of the “*crinitus*” group, such as *A. paraceryone*, a form somewhat analogous but much less accentuated. The two hooks of the dactyl are almost equal and a little divergent.

The telson bears on its posterior border 11 plumose hairs between the inner spines, which are 3 times as long as the outer spines. The external ramus of the uropod bears a small movable spine between two adjacent teeth.

The type is a female from Andros Island, Bahamas; F. Stearns collection (Cat. No. 38409, U.S.N.M.).



## SYNALPHEUS RATHBUNÆ, new species.

The frontal margin suggests *S. goodii*; the rostrum is narrow, with parallel margins, hardly one-sixth of the width of the lateral teeth and slightly longer; the lateral teeth have almost exactly the form, inverted, of the intervals between them and the rostrum, but a little narrower.

The articles of the antennule are to one another as 1.2, 1, 1; they are a little wider at the distal extremity and the flagella are stout; the stylocerite reaches the distal third of the basal article.

The superior angle of the basicerite is prolonged in a strong spine reaching as far forward as the stylocerite. This is the only case that

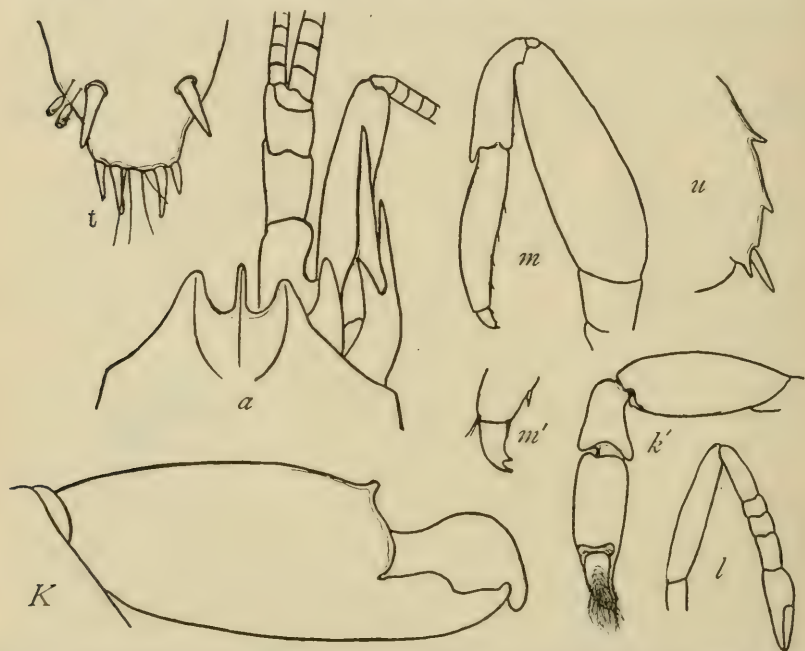


FIG. 51.—SYNALPHEUS RATHBUNÆ. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON; *u*, UROPOD.

I have as yet noticed in the LEVIMANUS group, so that this detail enables one to identify the species immediately. The outer spine, rather slender, reaches the middle of the distal antennular article.

The scaphocerite is reduced to its lateral spine, which has a concave inner margin, is much wider than the spine of the basicerite, and reaches the middle of the distal antennular article. The carpocerite surpasses the antennule by hardly one-half of the same article; it is 4.6 to 4.8 times longer than wide.

The proportions of the large chela are: Fingers 1; total length 3.5; height 1.25. But I have also found in one of the few specimens car-

rying eggs the proportions 1, 3, 1.2. The palm bears in front a conical tubercle, not spinose, pointing obliquely upward. The movable finger slightly exceeds the fixed finger.

The small chela measures: Fingers 1; total length 2.6; height 0.95. The fingers terminate in a single point. The carpus measures 0.5 of the whole chela. The meropodite is very thick, only 2.35 times as long as wide.

The second pair is very remarkable in that the carpus has only four articles. I have encountered the same number in young specimens of *S. longicarpus*, and especially of *S. brooksi*, but very exceptionally. Here it is a constant character. It is not certain, to tell the truth, that the specimens examined are normal, at least the females. In about thirty of the specimens I have been able to find only five carrying eggs. Four of these females each possess but one egg, the fifth has only three. Their abdominal pleura are not only very slightly developed, but they are all terminated by a very sharp point, and the second pleuron is hardly wider than the first and the third. As the total length of the largest specimen is 7.5 mm., it is possible that I have had in my hands only dwarfed or emasculated individuals, not showing the true sexual characters of the species. Perhaps in specimens of larger size, if such exist, the second pair would have five segments in the carpus, as in the great majority of the Alpheidæ, the genus *Arete* (with four segments) being the only exception.

The proportions of the third pair are: Meropodite 2.2; carpus 1; propodite 1.4. The meropodite, very massive, is only 2.8 times longer than wide. The two hooks of the dactyl are parallel and equal in length, the ventral, however, the stronger.

The spines of the dorsal face of the telson are very long and strong. Between the spines of the posterior margin are four plumose hairs. The outer uropod bears three teeth and a longer movable spine very close to the first tooth.

Named for Miss Mary J. Rathbun, of the U. S. National Museum.

This species recalls especially *S. pescadorensis* Coutière, of the Malayan Archipelago; besides the exceptional character of the second pair of feet, it differs from the latter species chiefly in the plume of hairs which surmounts the finger of the small chela, as in all the species of the *LÆVIMANUS* group.

#### Localities:

Porto Rico, Mayaguez Harbor, 22 to 33 fathoms, *Fish Hawk* Station No. 6064, on dead sponges, 30 specimens, of which about 5 are females.

Vieques, 12½ fathoms, *Fish Hawk* Station No. 6095, 1 specimen.

St. Thomas, 20 to 30 fathoms, *Fish Hawk* Station No. 6079, 7 specimens, types.

*Type*.—Cat. No. 38410, U.S.N.M.

## SYNALPHEUS PARANEPTUNUS, new species.

The tridentate region joins imperceptibly the rest of the frontal margin; the rostrum is 1.5 times longer than the lateral teeth, and of the same width; these teeth are sharp-pointed at the extremity, while the end of the rostrum is rounded.

The articles of the antennule are as 2, 1.3, 1. The stylocerite equals the basal article. The superior angle of the basicerite is a right angle, and well marked; the lateral spine reaches the middle of the median antennular article.

In the females the scaphocerite is almost wholly destitute of a scale. In the males it possesses one, which is always very narrow and in length varies between the extremity of the basal article and the

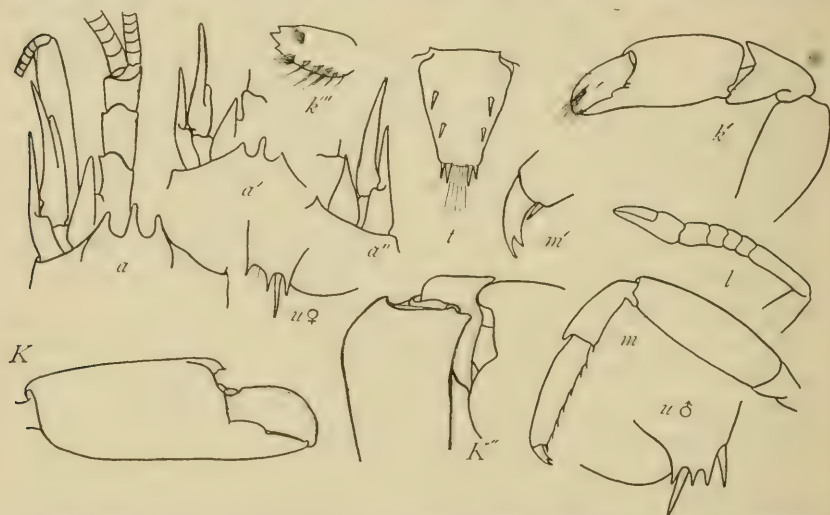


FIG. 52.—SYNALPHEUS PARANEPTUNUS. *a*, FRONTAL AND ANTENNAL REGION OF TYPE MALE; *a'*, FRONT AND BASE OF ANTENNAE OF ANOTHER MALE WITH ANTENNAL SCALE MORE REDUCED; *a''*, FRONT AND BASE OF ANTENNAE OF FEMALE WITH ANTENNAL SCALE ABSENT; *K*, LARGE CHELA; *K''*, MEROPODITE AND CARPUS OF LARGE CHELIPED; *k'*, SMALL CHELIPED OF FIRST PAIR; *k'''*, FINGER OF SAME; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON; *u*, UROPOD, MALE AND FEMALE.

distal third of the median antennular article. The lateral spine is considerably wider than that of the basicerite and as long as the antennule.

The carpopodite surpasses the antennular peduncle by the length of the basal article, and is 6 times as long as wide.

The proportions of the large chela are: Fingers 1: total length 3; height 1. The anterior margin of the palm bears a strong tubercle terminating in a small conical point directed downward.

The meropodite is strongly convex on its superior margin, especially near its extremity, where it forms a slight triangular prominence.



The proportions of the small chela are: Fingers 1; total length 3; height 1.17. The carpus measures only 0.4 of the entire chela. In the females these proportions become 1, 2.66, 1.06; the fingers being relatively longer, and the carpus measures 0.45 of the entire chela. The movable finger, seen from above, is oval in form and terminates in three unequal teeth, situated in the same horizontal plane; it is a little excavate below, and the lateral teeth mark the extremity of the thin and sharp lateral margins. The tuft of hairs is still present, but it is disposed in only five transverse rows, each numbering six hairs at most. This disposition is very interesting, as marking one of the extremities of the series of forms which compose the *LEVIMANUS* group. In the allied species, like *S. laticeps* Coutière and *S. neptunus* Dana, the armature of hairs of the small chela either does not exist or else is very much reduced and differently disposed.

*S. rathbunæ*, described elsewhere, is like a second entrance into the *LEVIMANUS* group through its close relations with *S. pescadorensis* and *S. bilinguiculatus*. This last species may serve to designate another group of forms, almost all from the Indian Ocean and the Pacific, whence the *LEVIMANUS* group seems to have sprung.

In the second pair the first segment of the carpus and the distal chela are perceptibly equal, the four other segments of the carpus slightly longer.

The proportions of the third pair are: Meropodite 2.2; carpus 1; propodite 1.5. The meropodite is a little more than 3 times as long as wide (3.1). The ischiopodite is shorter than in the other species of the group, and the dactyl is also of different form, inclining toward such forms as *S. minus*; the two margins converge slightly and the article is as if split into two parallel hooks, the dorsal a little longer.

The height of the telson equals 1.23 times its base, 2.9 times the posterior margin; the inner spines of the latter are twice as long as the outer, and between them are five plumose hairs and two pairs of simple hairs.

The outer uropod bears 3 to 4 contiguous teeth and a movable spine between the first two.

The eggs give rise to zoëæ.

The species is very close to *S. neptunus* Dana, of which I have been able to examine two typical male examples from the Sooloo Sea. The rostrum is slightly longer and narrower than the lateral spines and 4.5 times longer than its middle width. The stylocerite is shorter than the basal antennular article. The superior angle of the basicerite is slightly acute, its lateral spine reaching the proximal third of the median antennular article. The scaphocerite bears, in both cases, a very narrow scale of the same length as the outer spine



of the basicerite: the lateral spine of the scale does not reach the middle of the distal article of the antennule. The carpocerite is only a little longer than the antennule (one-half of the distal article) and is 5.3 times longer than wide.

The proportions of the large chela are: Fingers 1; total length 4.15; height 1.7. The anterior border of the palm is terminated by a strong horizontal prominence, conical and sharp-pointed. The meropodite has its superior margin unarmed; it is 2.25 times longer than wide.

The proportions of the small chela are: Fingers 1; total length 2.25; height 0.75; the fingers are almost as long as the palm. The movable finger is enlarged laterally, and bears on each margin 5 to 7



FIG. 53.—*SYNALPHEUS NEPTUNUS*. *a*, FRONTAL AND ANTENNAL REGION OF A TYPE MALE; *a'*, FRONTAL AND ANTENNAL REGION OF ANOTHER TYPE MALE WITH BASICERITE MORE SPINOUS; *a''*, FRONT; *K*, LARGE CHELA; *K''*, CARPUS AND MEROPODITE OF LARGE CHELIPED; *k*, SMALL CHELA OF FIRST PAIR; *k'*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR; *t*, TELSON; *u*, UROPODS.

hairs regularly spaced, which are perhaps the first indication of the transverse series of hairs present in all of the *LEVIMANUS* group. Each of these fingers is terminated by a single point. The carpus measures only 0.25 of the entire chela, a proportion which is never attained in the *LEVIMANUS*. The two chelæ are in the proportion of 1 to 2.

The second pair has very peculiar proportions, the first segment of the carpus 1, the sum of the four following segments 2, distal chela 2.

The proportions of the third pair are: Meropodite 2.3; carpus 1; propodite 1.9; meropodite 4 times as long as wide. The two hooks of

the dactyl are divergent, the ventral stronger, almost perpendicular to the inferior margin.

The height of the telson equals 1.5 times its base, 3.5 times its posterior margin. The latter has two pairs of weak spines, between which the convex margin bears 7 to 8 plumose hairs. The outer uropod carries a movable spine between two teeth slightly marked.

The length of the cephalothorax is 3 mm.

Localities:

Jamaica, *Albatross*, 1884, 2 specimens.

Near Monosquillo, 42 fathoms, *Albatross* Station No. 2142, 1 specimen, type, Cat. No. 7770, U.S.N.M.

LIST OF EXTRA-AMERICAN SPECIES IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM.

SYNALPHEUS ALBATROSSI, new species.

This species, represented by only one female specimen of small size, belongs in the COMATULARUM group, which it binds to the other groups of forms in a very instructive manner.



FIG. 54.—SYNALPHEUS ALBATROSSI. *a*, FRONTAL AND ANTENNAL REGION; *K*, LARGE CHELA; *K''*, CARPUS AND MEROPODITE OF LARGE CHELIPED; *k*, SMALL CHELIPED OF FIRST PAIR; *l*, FOOT OF SECOND PAIR; *m*, FOOT OF THIRD PAIR; *m'*, DACTYL OF THIRD PAIR.

The frontal spines are large, almost equal in length and with concave borders; rostrum wider than the lateral teeth. The antennular peduncles are short and stout, the stylocerite equal to the basal article.

The basicerite bears two very short spines, the inferior a little longer, but not attaining the extremity of the frontal spines. The scale of the carpocerite is large, its lateral spine equals the carpocerite, which is 3.7 times as long as wide, and scarcely surpasses the antennules.

The distal article of the outer maxillipeds is only 3.6 times as long as wide, this proportion being 6 times in *S. minus*, for example.

The proportions of the large chela are: Fingers 1; total length 3.5; height 1.4. It tapers from behind forward, and bears a weak conical prominence on the palm, continuing the upper margin. Meropodite very thick and unarmed, only twice as long as wide.

The small chela, the carpus of which is short, has the following proportions: Fingers 1; total length 3; height 1. The fingers end in an obtuse point.

The second pair is slender, the first segment of the carpus longer than the sum of the 4 others, the distal chela small. The following feet are also slender, the meropodite being 4.5 times as long as wide. The dactyl is elongate and is terminated by two parallel hooks, the ventral a little shorter and thicker, a form which recalls the species of the *PAULSONI* group.

The telson is like that of the species of this group, its posterior margin being very little convex.

Laysan Island, 10 to 19 fathoms, *Albatross* Station No. 3960, 1 female, 9 mm. long, type, Cat. No. 38344, U.S.N.M.

*SYNALPHEUS CHARON* (Heller).

Hawaiian Islands, *Albatross* Stations Nos. 3955, 3962, and 4073.

*SYNALPHEUS PARANEOMERIS* Coutière.

Hawaiian Islands, *Albatross* Stations Nos. 3921, 3960.

*SYNALPHEUS GRAVIERI* Coutière.

Southern Japan, *Albatross* Station No. 3729.

*SYNALPHEUS LÆVIMANUS* (Heller).

Adriatic Sea.

*SYNALPHEUS NEOMERIS* de Man.

Shanghai.

DESCRIPTIONS OF NEW EXTRA-AMERICAN SPECIES MENTIONED IN THIS PAPER, BUT NOT IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM.

*SYNALPHEUS MEROSPINIGER*, new species.

Very near *S. neomeris* de Man, differing especially in the dactyl, the two hooks of which are almost equal. The supraorbital spines are also wider, the antennular peduncle more robust (ratio of length to

width 1:4.5 instead of 1:5 in *S. neomeris*), the stylocerite longer, and the carpocerite more slender (ratio 1:4.4 instead of 1:4).

Amirante Islands, Seychelles Group; Percy Sladen Trust Expedition.

Type in Paris Museum.

SYNALPHEUS TRIONYCHIS, new species.

Very close to *S. fossor* Paulson, differing in the carpocerite which has the proportion of 1:5 instead of 1:6, in the large cheliped spinous on the palm and the merus, in the small chela less thick than its meropodite, and in the stronger feet of the third pair; in the dactyl of this member the ventral supernumerary hook is sharp and directed forward, and the dorsal hook is almost as long as the principal hook.

Saya de Malha, western Indian Ocean; Percy Sladen Trust Expedition.

Type in Paris Museum.

SYNALPHEUS BAKERI, new species.

Allied to *S. triunguiculatus* Paulson, from which it differs in the rostrum 1.5 times as long as the lateral spines, the carpocerite stout (ratio 1:3.6 instead of 1:4.5), and shorter than the antennal spine, the palm of the large chela unarmed, and the meropodites of the two chelipeds almost unarmed. The dactyl of the third and fourth pairs is much smaller, and the ventral supernumerary hook is not one-third of the principal hook, while it is three-fourths of the same in *S. triunguiculatus*.

South Adelaide, South Australia; M. Baker, collector, for whom it is named.

Type in Paris Museum.

SYNALPHEUS PHYSOCHELES, new species.

Differs from *S. triunguiculatus* Paulson, especially in the large chela, the palm of which is very swollen and the fingers extremely short (fingers 1, total length 5.33, height 2.2). The fingers of the small chela are contained 3 times in the total length (instead of 2.7 times). The feet of the third pair are more slender, the meropodite being 4 times and the propodite 7 times longer than wide (instead of 5.5 and 3.3 times).

Djibouti, French Somaliland; Ch. Gravier.

Type in Paris Museum.

SYNALPHEUS OTIOSUS, new species.

Differs from *S. paranomeris* Coutière in the shorter carpocerite ratio 1:3 instead of 1:4), in the unarmed meropodite of the large cheliped, that of the third pair stouter (ratio 1:3.5 instead of 1:4), the propodite of 5 spines instead of 8, the telson wider at its distal extremity (proportion of the bases 1:1.5 instead of 1:1.85).

Cœtivy Island, Seychelles Group; Percy Sladen Trust Expedition.

Type in Paris Museum.



## SYNALPHEUS PAULSONI LIMINARIS, new subspecies.

Differs from *S. paulsoni* Nobili in the superior spine of the basicerite being almost wanting, in having the carpocerite a little more elongate, at least 3.5 times as long as wide (2.9 to 3.1 in *S. paulsoni*), and in having the palm of the large chela always terminated by a strong anterior spine.

Djibouti, French Somaliland; Ch. Gravier. Persian Gulf; Bonnier and Perez.

Type in Paris Museum.

## SYNALPHEUS PAULSONI SENEGAMBIENSIS, new subspecies.

Differs from all the other forms of *S. paulsoni* by the more slender carpocerite (ratio 1:3.7), which approaches that of *S. hululensis*, but the superior spine of the basicerite is more slender than in that species, the posterior angles of the telson right angles and the meropodite of the small cheliped is unarmed on its superior border (the large cheliped is lacking).

Cape Verde; *Talisman*.

Type in Paris Museum.

## SYNALPHEUS MUSHAENSIS, new species.

Differs from very similar forms of the PAULSONI group, by the carpocerite (proportion 1:3.6) surpassing the antennule by the whole length of the distal article of the latter; by the scaphocerite, the scale of which is wide and shorter than the antennule, while its lateral spine exceeds it very slightly; by the stylocerite not reaching beyond the inferior spine of the basicerite. The large claw has short fingers (proportions: fingers 1, total length 4.2, height 1.6), the palm bears a feeble flattened prominence on its anterior margin, the supero-external margin of the meropodite is spinous. The small claw has the following proportions: fingers 1, total length 3.12, height 1. The posterior angles of the telson are right angles except for a very slight spinous prominence ( $\frac{1}{4}$  of the outer spine).

Musha Islands, Gulf of Aden; Ch. Gravier.

Type in Paris Museum.

## SYNALPHEUS MACCULLOCHI, new species.

Closely allied to *S. paulsoni kurracheensis*, but differs especially in the large size of the eggs, which produce mysis larvæ, as in *S. tumidomanus* Paulson. The rostrum is narrower and longer, the spine of the basicerite much slenderer. The carpocerite has the same proportions. The palm of the large chela is unarmed. The meropodite of the third pair is 4.5 times as long as wide, instead of 4 times.

Port Jackson, New South Wales (type); A. McCulloch, for whom the species is named. South Adelaide, South Australia; H. W. Baker.

Type in Paris Museum.

SYNALPHEUS LOPHODACTYLUS, new species.

Differs from *S. biunguiculatus* Stimpson in having the basicerite unarmed above, the posterior angles of the telson spinous, and the movable finger of the small chela bearing a dorsal brush of hairs and not some lateral bunches. Furthermore, the antennular peduncles and the carpocerite are short (ratio 1:4 for both), the antennal scale is large, the feet of the third pair are slender (proportions of the meropodite 1:4.5 instead of 1:3 in *S. biunguiculatus exilipes* Coutière, which approaches it the most in this regard).

Diego Garcia, Chagos Archipelago; Percy Sladen Trust Expedition.

Type in Paris Museum.

SYNALPHEUS SLADENI, new species.

Differs from all the other species of the LEVIMANUS group by the considerable prominence of the frontal border, the basicerite being feebly spinous below, the antennal scale large, the large chela cylindrical, almost 3.5 times as long as high, the feet of the third pair slender (proportions of the meropodite 1:5.4), and the telson very narrow with posterior right angles. It approaches the species of the COMATULARUM group, while the small chela is altogether comparable to that of *S. longicarpus*.

Cargados Carajos, western Indian Ocean: Percy Sladen Trust Expedition (to which the specific name is dedicated).

Type in Paris Museum.



# ON THE SKULL AND THE BRAIN OF TRICERATOPS, WITH NOTES ON THE BRAIN-CASES OF IGUANODON AND MEGALOSAURUS.

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Two circumstances recently stimulated the writer to make a study of the skull of the Ceratopsia. One of these was the sight of a nearly complete brain-case of a specimen that has been identified as *Triceratops serratus* (Cat. No. 2416, U.S.N.M.); the other was the appearance of Hatcher's monograph entitled *The Ceratopsia*, which was published in 1907 as Monograph 49 of the U. S. Geological Survey.

Inasmuch as some statements are made in Hatcher's monograph regarding the structure of the skull of the Ceratopsia from which the writer must dissent, it is desirable to express admiration for that important work. For the first time there is brought together all that is known about these bizarre reptiles. They form a difficult subject of investigation, and no one writing about them can expect either to avoid errors or to exhaust the subject. Therefore, every student of the group needs to look with charity on the shortcomings of others. We are under the highest obligations to Hatcher, Marsh, and Lull, as authors of *The Ceratopsia*.

The principal difficulty in the way of explaining the brain-case of the Ceratopsia is found in the thorough coossification of most of the component bones. Such is the condition of the brain-case referred to in the first paragraph of the present paper. This specimen (Plate 1, fig. 1; Plate 2, fig. 1) was collected for Professor Marsh in 1889 by O. A. Peterson, on Lance Creek, Converse County, Wyoming. It is not mentioned in *The Ceratopsia* under *T. serratus*, but Hatcher's figs. 32 and 34 were taken from casts which represent the brain that once filled that specimen. In the legend under these figures the number of the specimen is given as 2065, but this is the accession number in Marsh's collection, not that of the U. S. National Museum.

As stated, most of the bones are united so as to abolish all traces of the sutures. However, the anterior, or orbitosphenoidal, segment has remained free from that behind, as will be shown.



The writer will first consider that unpaired bone which was regarded by Marsh and Hatcher as the supraoccipital.<sup>a</sup> This question needs to be answered: How can that bone be the supraoccipital which overlies, as this one does, the midbrain instead of the medulla oblongata and the cerebellum? Furthermore, it appears quite improbable that the supraoccipital alone of the bones of the occipital segment would fail to coossify with the others. However, what seems to be an unanswerable argument against the identification of this bone as the supraoccipital is the fact that the latter bone in reptiles takes an essential part in the formation of the internal ear, including on each side, as it does, always some part of the posterior semicircular canal. It may be said that its right and left borders are thereby firmly anchored to those other bones that enclose portions of the semicircular canals, the opisthotic and the prootic. Now, if the bone called supraoccipital by Marsh and Hatcher is such, the semicircular canals would have to make a loop about 100 mm. long in order to reach the supraoccipital.

The fact appears to be that this bone has been wrongly identified. The true supraoccipital is that bone which forms the roof over the medulla oblongata, and which in the specimen here studied and in all others known is ankylosed to the exoccipitals on each side. Whether or not the latter join each other over the foramen magnum can not now be determined. In *Camptosaurus* the supraoccipital forms a considerable part in the boundary of the foramen magnum, but in crocodiles no part. As shown by Hatcher's fig. 8, the lower border of the bone called supraoccipital rests on the side walls of the brain-case, his alisphenoid, as far forward as the "alisphenoid buttress for the postfrontal;" but these are almost exactly the relations that the parietal has in the alligator. Unfortunately, in the specimen before us the bone regarded by the writer as the parietal is missing, except a part of the left side, whose broken edge is seen in fig. 1, Plate 2, *pa*. From No. 4286, *T. sulcatus*, described below, it appears that the suture between the parietal and the alisphenoid would run along the lower border of the broken surface just referred to, but it would probably strike the outer surface of the brain-case much below the upper border of the broken surface shown in the figure mentioned.

It would appear that the editor of *The Ceratopsia* himself, who lettered the figures of Hatcher's work, was now and then either in doubt regarding the identity of the supraoccipital and the parietal or was led instinctively to their correct determination. Fig. 107, on p. 121, represents as supraoccipital a portion of the bone called exoccipital in fig. 6; while that bone which in the former figure is denominated parietal is represented in fig. 6 as being the supraoccipital.

<sup>a</sup> Marsh, *Dinosaurs of North America*, p. 210; Hatcher, *The Ceratopsia*, pp. 16, 17, figs. 7, 8.

Nevertheless, in the text the foramen magnum is said to be wholly in the exoccipitals and the median expanding bar of bone is said to articulate with the supraoccipital. Also, the supraoccipital is correctly represented on Plates 33 and 37 of *The Ceratopsia*.

Of course, the question at once comes up regarding the composition of the frill. It has always been interpreted as consisting of the squamosals on the right and left borders and of the coalesced parietals in the middle part. There seems to be no doubt that the bones called squamosals are such. For the middle portion we must seek some other bone or bones than the parietal. It seems to the writer that the required elements are to be found in the supratemporals, bones found in many lizards and in some other reptiles. For those of the lizard, see Parker.<sup>a</sup> Or, it seems possible that the middle bone of the frill may have developed from the coalescence of nuchal bones such as are found in the crocodiles.

On each side of the frill of *Triceratops*, between the squamosal and the so-called parietal, there is an elongated excavation which terminates farther in front in a foramen, and this excavation has been called the supratemporal fossa. Now, it is easy to see that in the alligator the hinder free borders of the parietal and squamosals might grow backward over the animal's neck and make such a frill as we have in *Triceratops*; but in this case the supratemporal fossæ would be left in their original position. It is difficult to understand how these bones became modified in such a way as to transfer the supratemporal fossæ behind the paroccipital processes of the exoccipitals.

It appears to the writer that the supratemporal fossæ have either been abrogated or not yet recognized as such. Marsh described an opening in the midline, slightly behind the great postorbital horn cores, and called it the pineal foramen; although he did not show that it opened into the brain and did conclude that it opened into a large sinus extending above the brain-case into the cavities of the horn cores. Hatcher and Lull likewise say that this foramen communicates with large sinuses in the postfrontal bones and in the horn cores. Furthermore, Lull<sup>b</sup> writes that the sinus underlaying the horn core can be explored through the so-called pineal, or postfrontal, foramen, and that the latter communicates with those of the horn cores and with the space within the skull behind the orbit. By the latter expression is understood by the present writer the space occupied by the temporal muscles, the space called by Hatcher the temporal fossa.<sup>c</sup> Probably in all cases this postfrontal foramen divides below

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<sup>a</sup> Trans. Phil. Soc. London, CLXX, pp. 595-640.

<sup>b</sup> Bull. Amer. Mus. Nat. Hist., XIX, p. 691.

<sup>c</sup> The Ceratopsia, p. 125.

into two, one for each side. Hatcher<sup>a</sup> says that in *Torosaurus latus* there is a pair of these foramina, separated by a thick partition of bone that marks the median line of the skull.

Now, to the writer it seems perfectly clear that the foramen in question represents the supratemporal fossæ of the alligator and of various other reptiles. The bone rising up and dividing the fossa into two, either at the surface or deeper down, will almost certainly be found to be the true parietal. Through the enormous thickening of the postfrontals the parietal has been crowded from the upper surface of the skull of *Triceratops* and the two supratemporal fossæ have been pushed into one at the midline.

As regards the fossæ in the frill, they may be explained as gaps between the squamosal and the supratemporal of each side. Hatcher<sup>b</sup> tells that these openings communicated with the temporal fossæ and with the cavities at the bases of the horn cores. These passages must represent the posttemporal fossæ. Possibly through them passed branches of the temporal arteries to spread themselves over the upper surface of the frill.

Hatcher has, in my opinion, erred in his interpretation of the brain-case of the Ceratopsia. His errors have arisen partly from the nearly complete or complete absence of sutures in the skulls examined and partly from his not having recognized the differences between the reptilian skull and that of the mammals, a group with which he was more familiar. The latter cause of error is shown in his failure to mention the prootic bone, one of the most constant in the reptilian skull, and in his speaking of all of the bones of the skull in front of the exoccipitals as the alisphenoid, as if it corresponded to the sphenoid of human anatomy. Again, on page 39 of *The Ceratopsia*, the organ of hearing is misunderstood because it did not present mammalian characters.

The specimen before me (Cat. No. 2416, U.S.N.M.) appears to agree quite closely with Hatcher's fig. 8 representing the same parts of *T. flabellatus*, although the latter is about a third larger than No. 2416. Now, in both skulls there are undoubtedly present the basioccipital, the basisphenoid, the presphenoid, exoccipitals, prootics, alisphenoids, and orbitosphenoids. In fact, it appears that the brain-case of the Ceratopsia was the most complete of any known reptile.

Inasmuch as the sutures between the bones are mostly effaced, we are able to determine their limits only approximately, guided partly by the orifices for the nerves, partly by the courses of the sutures in living reptiles, but especially by aid from the fine skull of *Camptosaurus* now being studied by Mr. Charles W. Gilmore, who has generously allowed the writer to examine it.

<sup>a</sup> *The Ceratopsia*, p. 151.

<sup>b</sup> *Idem*, p. 125.



The identification of these bones and foramina may begin with the foramen ovale, that opening through which the fifth nerve escapes from the brain cavity. This has been correctly identified by Hatcher.<sup>a</sup> In Cat. No. 2416 this foramen has, on the inner surface of the brain-case (Plate 2, fig. 1, 5), a diameter of about 12 mm., and it is of a somewhat squarish form. On the outer surface (Plate 1, fig. 1, 5<sup>2</sup>, 3) the diameter is about 16 mm. The bone here has a thickness of about 28 mm. It may be here remarked that the foramina of this skull are usually really short canals, having inner and outer ends. In the passage for the fifth nerve, not far from its inner end, there is given off a large canal which is directed forward, emerging on the outer surface of the skull about 30 mm. in front of the foramen ovale (Plate 1, fig. 1 5<sup>1</sup>). Through this canal passed forward the ophthalmic branch of the fifth nerve. Hatcher writes that the anterior opening is the foramen rotundum, and conveyed the maxillary branch; but the structures here are identical with those in the alligator. Out of the external end of the foramen ovale (Plate 1, fig. 1, 5<sup>2</sup>, 3) issued the second and the third branches of the fifth nerve.

Now, the foramen ovale is situated between the prootic and the alisphenoid bones. In the alligator the larger part of it is in the prootic; and the same is the case in *Camptosaurus*. Hence, in *Triceratops* the suture between the prootic and the alisphenoid may be provisionally drawn through the front of the foramen, carrying the suture up to the parietal.

On the inner surface of the brain-case (Plate 2, fig. 1, 6), a little below the foramen ovale, there is seen the posterior orifice of a canal 4 mm. in diameter, for the transmission of the sixth nerve, just as may be seen in the alligator. The canal runs the length of the basisphenoidal bone, emerging at its anterior end. In Hatcher's fig. 8 it is indicated by the letter *z* and explained as being an undetermined foramen.

In Hatcher's figure just quoted there is indicated by the letters *cam* a small foramen just behind the foramen ovale. This is explained with a query as being the internal auditory meatus. Being on the outside of the brain-case it can not be that meatus. In fig. 24 the same foramen is said to be the external auditory meatus. The meatus properly so-called is a part of the external ear and this reptile probably had no such organ. The foramen in question is that for the escape of the seventh, or facial, nerve (Plate 1, fig. 1, 7). It has the same position as in the alligator and, as in the latter animal, goes straight through the prootic bone. Outwardly it opens between two descending ridges of bone, which enclose a smooth groove, along which the nerve passed downward. A similar groove is seen in the alligator and in *Camptosaurus*.

<sup>a</sup> The Ceratopsia, p. 17, fig. 8, *fo*.



On the inner surface of the brain-case, behind the foramen just described, is a large oval opening (Plate 2, fig. 1, 10) whose greater axis, 18 mm. long, is directed upward and backward. Hatcher (p. 16) has called this the foramen lacerum posterius. It is the common mouth of two short canals which emerge, the one behind the other, on the outer surface of the skull (Plate 1, fig. 1, *fen* and 10). Between the two exterior openings there is a great ridge of bone 10 mm. thick, that ascends from the basioccipital process to the paroccipital process of the exoccipital. In the alligator a corresponding ridge forms the lateral boundary of the lower part of the exoccipital, and it is probable that in *Triceratops* the ridge is on the exoccipital. The anterior of the two exterior openings mentioned is the larger. It is funnel-shaped, the mouth of the funnel having a horizontal diameter of about 20 mm. and a vertical diameter of 15 mm. The hinder canal likewise expands as it approaches the surface, and forms a triangular foramen whose diameters are about 10 mm. and 15 mm. In the figure referred to last this opening is hidden by the ridge of bone described. The line from 10 is directed to it.

Hatcher<sup>a</sup> has identified the anterior of these foramina as the outer end of the foramen lacerum posterius, the hinder as the place of exit of the tenth and eleventh nerves. However, on page 37 he writes that he has interpreted the anterior branch from the internal foramen lacerum posterius as having conveyed the tenth nerve to the brain. He there states further that some anatomists may regard the anterior of the two outer foramina as the external auditory meatus, its internal opening as the internal auditory meatus.

There is no doubt in the mind of the writer that the anterior of the outer foramina in question is the fenestra ovalis, the opening into the vestibule of the internal ear. In life it was probably partly or wholly closed by the expanded end of the stapes. So far as known to the writer, this bone has not yet been found in any member of the Ceratopsia. It was quite certainly a long slender rod, which extended from the fenestra ovalis to the outer surface of the skull, running first below the paroccipital process, then behind the quadrate, reaching the skin in the notch found in the lower border of the frill. It could hardly have been less than a foot in length. A very similar stapes is found in the alligator and in most other reptiles.

The hinder of the two external foramina discussed above is the proper foramen lacerum posterius, or jugular foramen (Plate 1, fig. 1, 10), and it transmitted the ninth, tenth, and eleventh nerves of its side, besides also the jugular vein. The foramen credited by Hatcher to the eleventh nerve is the anterior condyloid foramen and probably transmitted a vein. The foramen for the twelfth nerve (Plate 1, fig. 1, 12) is correctly identified.

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<sup>a</sup>The Ceratopsia, p. 16, fig. 8.

We must now investigate further that opening on the inner surface of the brain-case (Plate 2, fig. 1, 8, 10) from which diverge the two short canals considered above, the one to the fenestra ovalis, the other to the foramen lacerum posterius. On comparison with the alligator there can be no doubt that we have here a confluence of the opening for the auditory nerve and that for the transmission of the ninth, tenth, and eleventh nerves, the lower part of the foramen having been devoted to the auditory, the upper part to the other nerves. In the alligator the latter nerves pass out through a long fissure, which is separated from the foramen for the auditory nerve by only a narrow process of bone. Had the cartilage of this process not become ossified the two openings would have appeared in the dried skull as a single one, as it does in *Triceratops*.

Hatcher thought that the foramen for the facial nerve, his internal auditory meatus, communicated with the small cavities which he represented in his fig. 31 and indicated by the numeral III. The cavities shown there are quite certainly sections of the anterior and posterior semicircular canals, the larger section being the commissure of the two canals. The anterior section belongs in the prootic bone, the posterior in the opisthotic portion of the exoccipital, while the larger section is in the line of union of the two bones. The supraoccipital bone must have descended nearly to the level of these sections. Communication with these canals was had from within the skull by means of the foramen transmitting the eighth nerve, from without by means of the fenestra ovalis. In all these respects we have here the normal reptilian condition, and we have no reason for thinking that the *Ceratopsia* were deficient in hearing.

Now, the fenestra ovalis lies between the prootic bone and that part of the exoccipital that had its origin from the opisthotic. The suture between the prootic and the exoccipital may then be drawn through the fenestra ovalis and carried upward to the supraoccipital, as it runs in the alligator and in *Camptosaurus*.

Slightly behind and about 28 mm. below the foramen ovale, that exit for the fifth nerve, is the mouth of the canal for the internal carotid artery (Plate 1, fig. 1, *car*). The other end of the canal is found in the pituitary fossa (Plate 2, fig. 1, *car*). The hinder opening appears to be in the posterior end of the basisphenoid bone. A long shallow groove (Plate 2, fig. 1, *car. g*) on the underside of the basioccipital process leads forward to it. From the front end of the pituitary fossa a short canal (Plate 2, fig. 1, *op. f*; Plate 1, fig. 1, *op. f*) runs forward and opens on the outer surface of the bone. The outer opening is indicated in Hatcher's fig. 8 by the letters *pf*. It seems probable that this canal conveyed to the orbit the ophthalmic branch of the internal carotid artery, a vessel that in man escapes through the optic foramen.

The optic foramina (Plate 1, fig. 1, 2; Plate 2, fig. 1, 2) have been correctly identified by Hatcher. Behind each of these openings is another (Plate 1, fig. 1, 3; Plate 2, fig. 1, 3) which he has correctly called the sphenoidal fissure. Through it passed to the orbit the third nerve and possibly the fourth. This fissure, or rather foramen, lies in the boundary between the orbitosphenoid and the alisphenoid bones. Indeed, in our specimen the suture between the two bones has remained open, so that the limits of the orbitosphenoidal segment may be traced. Each optic foramen is in the orbitosphenoid of its side, near its hinder edge. The bones of the two sides meet above the olfactory lobes and the suture is closed, but over the cerebral hemisphere there is a fontanel, which was closed by either the frontals or the postfrontals. As shown by Hatcher's fig. 27, *al*, the orbitosphenoids met over the olfactory lobe. The cerebral hemispheres and the olfactory lobes of *T. serratus* rested on what must be regarded as the presphenoid bone (Plate 1, fig. 1, *pre*; Plate 2, fig. 1, *pre*). This is a triangular plate which, just in front of the optic foramina, descends 50 mm. below the floor of the brain-case, while anteriorly its free border rises to the place of exit of the olfactory nerves. Its lower hinder angle is thin, but the bone thickens toward the brain. Its hinder border appears to have joined the basisphenoid by a suture not closed at the death of the animal. Hatcher's fig. 27 shows the presphenoid of *T. horridus*. The lower line leading from *al* is directed to it. In our specimen of *T. serratus* the sutures between the presphenoid and the two orbitosphenoids are obliterated, as they were in *T. horridus*. The upper surface of each orbitosphenoid is very rough, for sutural union probably with the frontals, although Hatcher's description (p. 18) and his figs. 9, 24, and 27 represent the postfrontals as pushing themselves below the frontals in this region.

Above the optic foramen, opening into the upper part of the brain-case and near the hinder border of the orbitosphenoid, are two smaller foramina (Plate 1, fig. 1, 4, *v.*; Plate 2, fig. 1, 4, *v.*), the one behind the other. From each, on the outer surface of the bone, a groove is directed forward for a short distance. It seems probable that the hinder of these gave exit to the fourth, or trochlear, nerve. The anterior must have transmitted a blood-vessel. The olfactory nerves (Plate 2, fig. 1, 1) left the brain-case through a single orifice; at least, no bony partition separated them as was the case with *T. horridus*. However, near the anterior end of the olfactory canal there is seen a longitudinal ridge on the upper midline, which formed a partial division of the olfactory lobe. The parietal formed most of that part of the roof of the brain-case which covered the optic lobes. Anteriorly it joined the united orbitosphenoids (Plate 2, fig 1, *pa*).



On the lower surface of that bone which the writer regards as the supraoccipital (Plate 2, fig. 1, *soc*), near its anterior end, apparently between it and the parietal, and placed right and left of the midline, are found two deep excavations. The mouth of each of these measures about 20 mm. fore and aft and about 15 mm. transversely. The depth amounts to 15 mm. The diameters diminish toward the upper ends of the excavations. The one on the left side (Plate 2, fig. 1, *ceb. f*) appears to have reached the external surface of the bone, forming a foramen. Whether the one on the other side reached the surface is uncertain, on account of some crushing. Into these excavations there penetrated probably portions of the brain. These will be considered below.

Near the upper border of each orbitosphenoid there is found another excavation similar to those just described, having a somewhat larger base, but not entering so deeply into the bone. The base measures 20 mm. fore and aft and 15 mm. transversely. From the front of each excavation a foramen (Plate 2, fig. 1, *v*) pierces the bone, as already mentioned.

Professor Marsh<sup>a</sup> published a figure of a cast of the brain-case of the specimen here described. This has been reproduced by Hatcher.<sup>b</sup> This figure represents a side view of the brain. Another figure giving a view of the lower surface of the brain of this specimen is published by Hatcher.<sup>c</sup> In that figure the letters VIII on the left side ought to be changed to VII; VIII should be connected with the anterior part of the mass indicated by X; and XI ought to be erased.

In order to represent more accurately the brain of this specimen, a new cast has been prepared by Mr. William Palmer, of the National Museum, under the superintendence of Mr. Gilmore and the writer. The parts of this brain, as represented by the cast, are indicated in the legend affixed to each figure of Plate 3. Attention must be specially called to certain structures found on the upper surface and which filled the excavations already mentioned. The hinder pair of these is shown on Plate 3, figs. 1, 3, *ceb. p*. These bodies are near the boundary between the cerebellum and the optic lobes. They are probably parts of the former. Andrews<sup>d</sup> interprets a strong development of brain substance in the same region in *Iguanodon* as the cerebellum; but that development formed a conspicuous band which culminated in the midline above. In *Triceratops* the lateral masses are far removed from each other. Marsh's figure of the brain does not adequately represent these masses.

On the upper surface of the anterior end of the brain there is seen another pair of processes (Plate 3, fig. 1, 3 *cer. h*), not rising,

<sup>a</sup> Dinosauurs of North America, pl. LXXVII, fig. 4.

<sup>b</sup> The Ceratopsia, p. 39.

<sup>c</sup> Idem, p. 37, fig. 32.

<sup>d</sup> Ann. Mag. Nat. Hist., 6th ser., XIX, p. 587, pl. xvi.



however, to such a height as the hinder pair. These probably represent the cerebral hemispheres. As mentioned above, there is a foramen placed at the front of each cerebral excavation. It probably transmitted blood-vessels; for certainly no nerve left that part of the brain.

The extensive space between the cerebellar processes and the cerebral hemispheres was probably mostly occupied by the optic lobes (Plate 3, fig. 1, *op. l*). Doubtless, an exact model of the brain would show here and farther in front a deep longitudinal cleft; also transverse clefts in front of the cerebellum and behind the cerebral hemispheres.

In Marsh's figure of the cast of the brain the olfactory lobe seems to be too long. In the figure here shown (Plate 3, figs. 1, 3, *olf. l*) it is a little too short. Its length is 55 mm. Where it escaped from the olfactory canal its divisions are seen to have been directed to the right and left, respectively.

#### THE BRAIN-CASE AND THE BRAIN OF *TRICERATOPS SULCATUS*.

In the U. S. National Museum there are important parts of a skull that has been identified as that of *T. sulcatus*. The specimen is Cat. No. 4286, U.S.N.M. It was collected by Mr. Hatcher in the so-called Laramie beds of Converse County, Wyoming, for the U. S. Geological Survey. Hatcher has presented a figure of the horn cores.<sup>a</sup> The brain-case, including the occipital condyle, has been sawed from the horn cores along a horizontal plane that passed somewhat above the cerebral hemispheres. Afterwards the brain-case has been divided along the median plane, thus exposing the brain cavity.

The sutures of this brain-case have been mostly, if not altogether, obliterated. The general structure is the same as that of *T. serratus*, but there are some minor differences of some importance. The orbitosphenoidal segment (Plate 2, fig. 2, *orbs*) is not so extensively developed, since nearly the whole of the olfactory lobe lay in front of the orbitosphenoids. The supraoccipital bone (Plate 2, fig. 2, *soc*) is thicker than in *T. serratus*. A part of the parietal is present. Whether or not it was consolidated with the supraoccipital is uncertain, but there seems to be an open suture. In front of its articulation with the supraoccipital a median sinus (Plate 2, fig. 2, *sin*) descends and is separated from the brain cavity by bone only 5 mm. thick. This represents probably the hinder of the two sinuses shown in fig. 33 of *The Ceratopsia* and indicated by the letter X. It seems to be bounded below by the parietal, and by possibly a part of the frontals. It is doubtful whether or not the orbitosphenoids of this species met above the olfactory lobe.

The presphenoid lacks much of being as large as it is in *T. serratus*. The basisphenoid (Plate 1, fig. 2, *bas*; Plate 2, fig. 2, *bas*) descends

<sup>a</sup> *The Ceratopsia*, p. 134, fig. 113.

a distance of 65 mm. below the surface of the brain, just behind the pituitary fossa. The bone in the region of this fossa has been damaged and replaced by white plaster. The fossa probably occupied the white area indicated by *pit. f.* in Plate 2, fig. 2. Its supposed hinder end is indicated there by a dotted line.

The writer has not been able to see the opening for the sixth nerve in this specimen. Possibly it pierced the bone farther forward than in *T. serratus*, at a point where the bone is damaged.

This specimen furnishes no certain evidence regarding the opening of the temporal fossa into the so-called post-temporal foramen. The upper parts of both temporal fossæ have been filled with plaster, in order to strengthen the specimen. On each side there is a passage from the temporal fossa into the cavity, or sinus, into which the so-called post-temporal foramen opens. On one side this opening seems to be partially artificial. On the other side it seems to be natural, but is possibly the result of accident. Here the opening is about large enough to permit the passage of one's finger.

#### THE BRAIN-CASE OF IGUANODON.

Hulke <sup>a</sup> has described a brain-case believed to belong to *Iguanodon*. The same specimen has been redescribed by Dr. C. W. Andrews, of the British Museum of Natural History.<sup>b</sup> A few remarks will be made on these descriptions.

Hulke has designated a part of the axis of the skull as equivalent to the basisphenoid and the presphenoid.<sup>c</sup> It is evident that the presphenoid is present. The basisphenoid appears to extend forward to the notch above the letters *ii*. That part of the axis beyond this notch is quite certainly the orbitosphenoid. It includes the optic foramen.

Judging from Hulke's and Andrews's accounts of this skull the ophthalmic branch of the fifth nerve left the common stem after the latter had passed wholly through the brain-case, and it then ran forward in a groove on the outer surface of the bone. In *Triceratops* the beginning of the canal that transmits this branch is deeply buried in the bone.

What Andrews regards as a foramen for transmitting a branch of the internal carotid artery into the brain cavity the present writer holds to be the exit of the seventh nerve. The nerve descended along the groove described by Andrews. What in Andrews's figure appears to be a foramen placed 18 mm. above the optic foramen may correspond to what in *Triceratops* is thought to be an opening for the

<sup>a</sup> Quart. Journ. Geol. Soc., XXVII, 1871, p. 199.

<sup>b</sup> Ann. Mag. Nat. Hist., 6th ser., XIX, p. 585.

<sup>c</sup> Quart. Journ. Geol. Soc., XXVII, 1871, pl. xi, figs. 1, 2, *bps*.

escape of the fourth nerve, as shown at the numeral 4 in the figures of Plates 1 and 2.

Andrews describes three closely placed foramina as being the fenestra ovalis, the exit of the glossopharyngeal nerve, and that of the jugular vein. One of these is certainly the fenestra ovalis, another may be the fenestra rotunda. The glossopharyngeal nerve and jugular vein may have passed out in company with the pneumogastric nerve. Andrews's statement regarding the forking of the passage by which the pneumogastric nerve leaves the brain cavity agrees with what is found in *Triceratops*.

As regards the cast of the brain cavity, the figure of which is furnished by Andrews, it seems to the writer that what is indicated as the root of the eighth nerve is really that of the seventh, while that indicated as the root of the ninth is in fact the root of the eighth. From what one sees in *Triceratops* one would expect to find the root of the ninth between the one just referred to and that of the tenth.

#### THE BRAIN-CASE OF MEGALOSAURUS.

Von Huene<sup>a</sup> has written an interesting account of the brain-case of *Megalosaurus*. This brain-case is short and high. That part of the lateral wall farthest in front is regarded by V. Huene as the alisphenoid. A notch at its lower end he rightly interprets as the point of exit of the optic nerve. To the present writer it appears that the region in front and above this notch is the orbitosphenoid. That portion of the wall that lies in front of the foramen ovale, rising to the parietal, must be interpreted as the alisphenoid.

V. Huene records the presence of a "meatus auditorius externus." Now, this meatus is a part of the external ear, and as this reptile probably did not possess such an organ, the foramen in question must have some other function. To the present writer it looks as if this foramen might be the outlet of the depression marked Z in V. Huene's fig. 1. This may be the summit of an excavation that contained such a process of the brain as has been described on page 103 as occurring in *Triceratops*.

What V. Huene calls the jugular foramen is almost certainly the inner and outer passages into the internal ear. On the inside of the brain-case this foramen admitted the auditory nerve; on the outside it was closed by the base of the stapes. The jugular vein doubtless escaped in company with the ninth and tenth nerves. V. Huene figures a foramen lying some distance above the one just mentioned and regards it as admitting to the inner ear the branches of the auditory nerve. The structures of the inner ear must lie lower down in the wall of the brain-case. Excavation of the bone lower down would certainly expose the semicircular canals. It is probable that the

<sup>a</sup> Neues Jahrb. Min., etc., 1906, I, p. 1, pl. 1, text figs. 1-4.



opening referred to corresponds to what the present writer has interpreted as the foramen for the fourth nerve. In V. Huene's fig. 3 there is represented an opening, marked T?, and thought by him to be the outlet for the nerve mentioned. It appears possible that this is only the anterior end of a canal that begins at the foramen assigned by V. Huene to the eighth nerve.

The Eustachian canal is mentioned by V. Huene as probably penetrating the vestibule (Vorraum) of the inner ear. This can not be true. The Eustachian canal opens into the middle ear, that portion lying outside of the fenestra ovalis and containing the stapedial rod.

Of the three foramina behind the foramen lacerum posterius the one marked *XII'* probably gave exit to the hypoglossal nerve; the ones marked *XII''* and *car* probably transmitted veins. It is not probable that the internal carotid artery found its way into the brain cavity at a point so far in the rear. It certainly entered at the pituitary fossa.

#### DESCRIPTION OF PLATES.

##### PLATE 1.

External view of the rear of the skull of two species of Triceratops.

Fig. 1. *Triceratops serratus*.  $\times \frac{3}{8}$ .

2. *Triceratops sulcatus*.  $\times \frac{3}{8}$ .

*als*, alisphenoid, on the crest of the alisphenoidal buttress to the postoccipital; *bas*, basisphenoidal process, broken away in fig. 1; *boc. p*, basioccipital process, complete in fig. 1, mostly missing in fig. 2; *car*, foramen for carotid artery, not seen in fig. 2; *fen*, fenestra ovalis; *oc*, occipital condyle, partly broken away in fig. 1, in fig. 2 the suture between the basioccipital and the exoccipital is seen below *oc*; *op. f*, foramen supposed to be for ophthalmic artery; *orbs*, orbitosphenoid; *par. p*, paroccipital process, broken away in both specimens; *pre*, presphenoid, small and not lettered in fig. 2; *v*, opening for supposed vein; 1, 2, 3, 4, foramina for cephalic nerves of corresponding numbers; 5, external opening for ophthalmic branch of the 5th nerve; 5<sup>2</sup>, 3, foramen for exit of second and third branches of 5th nerve; 6, 7, 10, 12, foramina for exit of corresponding cephalic nerves.

##### PLATE 2.

Longitudinal section of the rear of the skull of two species of Triceratops, showing the brain cavity:

Fig. 1. *Triceratops serratus*.  $\times \frac{3}{8}$ .

2. *Triceratops sulcatus*.  $\times \frac{3}{8}$ .

*a. c. f.* anterior condyloid foramen; *als*, alisphenoid; *bas*, basisphenoid, partly broken away in fig. 1; *boc*, basioccipital; *boc. p*, basioccipital process; *car*, foramen for left carotid artery entering pituitary fossa, not seen in fig. 2; *car. g*, groove for right carotid artery; *ccb. f.* foramen? at extremity of a cerebellar process; *oc*, occipital condyle; *op. f*, foramen for exit of left ophthalmic artery from pituitary fossa; *orbs*, orbitosphenoid; *pa*, parietal; *pit. f*, pituitary fossa; *pre*, presphenoid, not lettered in fig. 2; *pro*, prootic; *sin*, base



of air sinus; *soc*, supraoccipital; *v*, opening for supposed vein; *x*, cavity in basioccipital; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, exits for nerves of corresponding numbers.

## PLATE 3.

Brain-casts of two species of *Triceratops*.

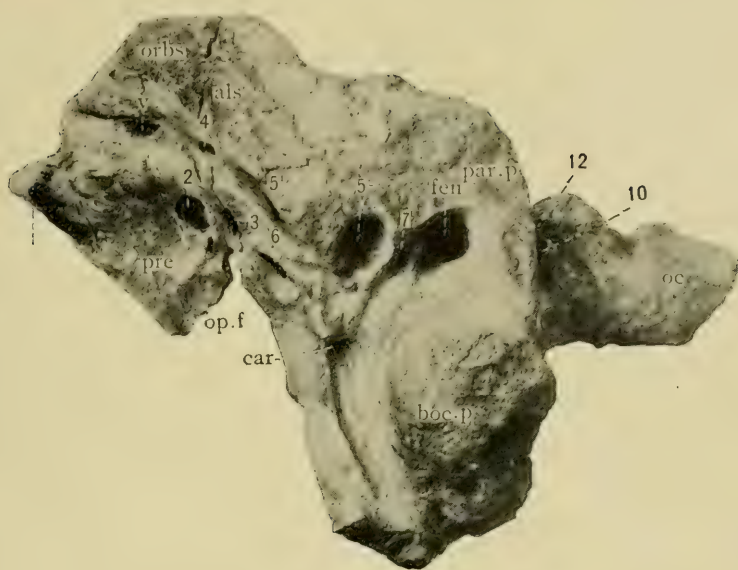
Fig. 1. *Triceratops serratus*. Upper surface.  $\times \frac{3}{8}$ .

2. *Triceratops serratus*. Lower surface.  $\times \frac{3}{8}$ .

3. *Triceratops serratus*. Right side.  $\times \frac{3}{8}$ .

4. *Triceratops sulcatus*. Right side.  $\times \frac{3}{8}$ .

*car*, entrance of carotid artery into pituitary fossa; *ccb. p.* process of cerebellum; *cer. h.* cerebral hemisphere; *mcd*, medulla oblongata; *olf. l.* olfactory lobe; *op. a.* base of supposed ophthalmic artery; *op. l.* optic lobes; *pit.* pituitary body, largely restored in fig. 2; *v*, veins; 2, 3, 4, optic, oculomotor, and trochlear nerves; 5, ophthalmic branch of 5th nerve; 5<sup>2-3</sup>, maxillary and mandibular branches of 5th nerve; 6, 7, 8, abducent, facial, and auditory nerves; 10, pneumogastric nerve, with probably the glossopharyngeal and the spinal accessory; 12, hypoglossal nerve.



1

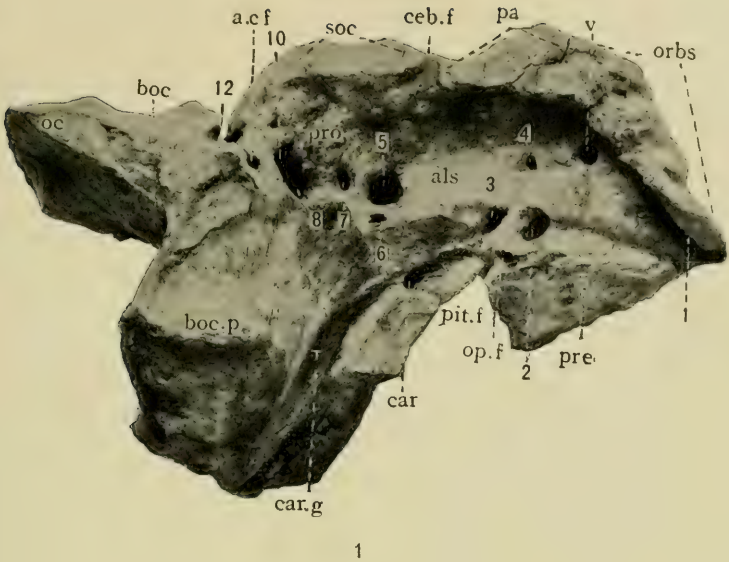


2

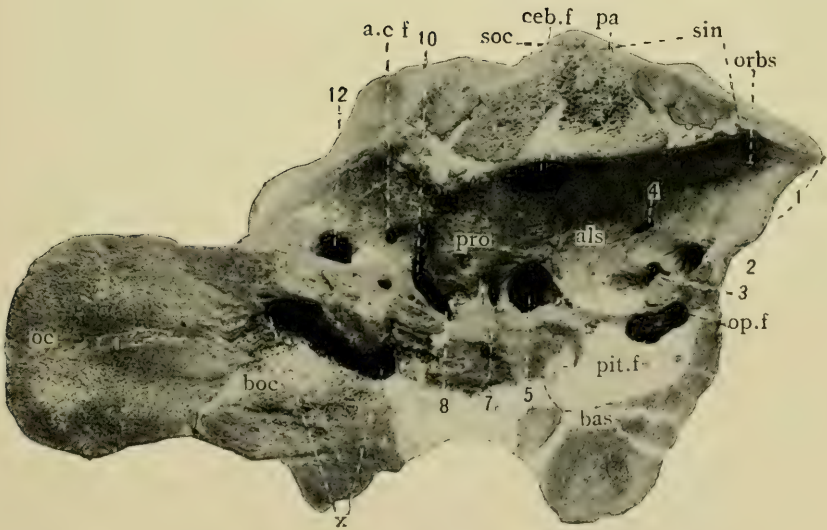
SKULLS OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGE 107.





1



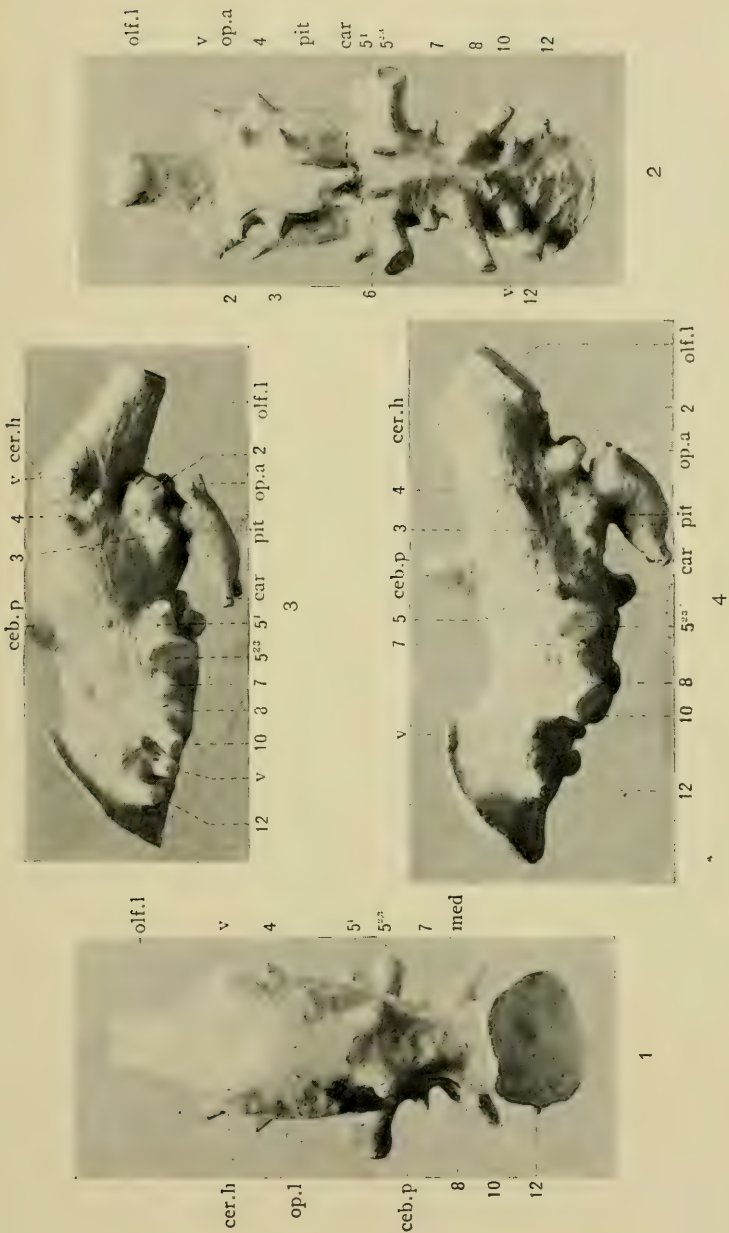
2

SKULLS OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGE 107.







BRAIN CASTS OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGE 107.



ON BRAZILIAN GRASSHOPPERS OF THE SUBFAMILIES  
PYRGOMORPHINÆ AND LOCUSTINÆ (ACRIDINÆ OF  
AUTHORS).

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By JAMES A. G. REHN,  
*Of the Academy of Natural Sciences of Philadelphia.*

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The following study is based upon a series of one hundred and ninety-two specimens of Brazilian Pyrgomorphinæ and Locustinæ belonging chiefly to the collection of the United States National Museum. Fifty-three species are treated in the paper, of which seventeen are new, four new genera also being described in these pages.

Of the series studied by far the greater portion is from the collections made by Mr. H. H. Smith in the State of Matto Grosso and at Rio de Janeiro, while a smaller series, taken by Mr. A. Koebele in northeastern Brazil in the States of Pernambuco and Bahia, is even proportionately more interesting.

My acknowledgments are due the authorities of the National Museum for their kindness in permitting me to examine the museum material. My thanks are here given also to Mr. Morgan Hebard, from whose collection was received for study a portion of the series here treated.

Subfamily PYRGOMORPHINÆ.

Genus ALGETE Bolivar.

1905. *Algete* BOLIVAR, Boletín Real Soc. Esp. Hist. Nat., V, p. 213.

*Type*.—*A. brunneri* Bolivar.

ALGETE BRUNNERI Bolivar.

1905. *Algete brunneri* BOLIVAR, Boletín Real Soc. Esp. Hist. Nat., V, p. 214.  
[Pernambuco, Brazil.]

Bonito, Pernambuco, Brazil, January 27, 1883. (A. Koebele.)  
[U.S.N.M.] One mature male, one immature female.

The above listed specimens clearly belong to this very distinct form. One individual is labeled "on cotton."



## Genus SPATHALIUM Bolivar.

1884. *Spathalium* BOLIVAR, Anales Soc. Esp. Hist. Nat., XIII, p. 30.

Included six congeneric species, of which the first, *S. sommeri* (Burmeister), can be considered the type.

## SPATHALIUM CYANOPTERUM (Blanchard).

1836. *Ommerecha cyanopterum* BLANCHARD, Ann. Soc. Ent. France, V, p. 608, pl. XXI, figs. 1 and 2. [Chiquitos, Brazil, now in Bolivia.]

Chapada, Matto Grosso, Brazil. April, September, and November. (H. H. Smith.) Three females.

These specimens are slightly or considerably smaller than Blanchard's measurement (38 mm. in length), but appear to belong to this species.

The variation in size in the individuals in hand is considerable, the extremes in length of the body being 29 and 32 mm., in the length of the pronotum 7.5 and 8, and in the length of tegmen 21.2 and 25.

Genus OMURA Walker.<sup>a</sup>

1870. *Omura* WALKER, Cat. Spec. Derm. Salt. Coll. Brit. Mus., III, p. 503.

Type.—*Omura congrua* Walker.

## OMURA CONGRUA Walker.

1870. *Omura congrua* WALKER, Cat. Spec. Derm. Salt. Coll. Brit. Mus., III, p. 504. [Para, Brazil; Amazon Region; Archidona, Ecuador.]

Benevides. July [one] (H. H. Smith). One male, one female.

There appears to be little doubt that Walker was in error in describing his specimens of this species as males, as the measurement given, as well as characters in the generic description, are clearly those of the female.

Stål's *Protomachus depressus* is possibly distinct from Walker's species, the shape of the rostrum and the space between the metasternal foveolæ as described appearing different from true *congrua*. The species *depressus* was described from Peru, Bolivar also recording it from the Upper Amazon. In addition to the localities given above, a series of twenty-three specimens of *O. congrua* from Bartica, British Guiana, have been examined by the author.

## Subfamily LOCUSTINÆ (ACRIDINÆ Authors).

## Genus PROCOLPIA Stål.

## PROCOLPIA MINOR Giglio-Tos.

Chapada, Matto Grosso. March and April. (H. H. Smith.) One male, one female.

<sup>a</sup>This name should replace *Protomachus* Stål. See Bolivar, Boletín Real Soc. Esp. Hist. Nat., V, p. 215.

These specimens are inseparable from Sapucay, Paraguay, individuals. The range of the species is here extended considerably to the northward, the type-locality, Colonia Risso, near the Rio Apa, northern Paraguay, having been the most northerly previous record.

Genus *CORYACRIS*,<sup>a</sup> new.

This new genus is closely allied to *Catreus* Stål, but differs in details best expressed in the diagnosis.

Fastigium somewhat produced, horizontal, sublanceolate, not deeply excavate; face regularly sloping without any marked division between line of fastigium and line of face; frontal costa sulcate; eyes prominent; antennæ depressed, slightly expanded proximad. Pronotum with the median carina straight, not appreciably elevated; lateral carinæ descending ventro-cephalad on the prozona. Tegmina elongate lanceolate, surpassing the abdomen. Prosternal spine compressed, slightly bulbous and distinctly retrorse distad; interspace between the mesosternal lobes distinctly longitudinal, between the metasternal lobes subquadrate to slightly transverse. Supra-anal plate of the male trigonal; cerci styliform; subgenital plate compressed, rostrate. Cephalic and median limbs rather robust, the femora appreciably inflated in the male. Caudal femora with the medio-dorsal portion of the genicular margin provided with a distinct spine, genicular lobes large; caudal tibiæ with an apical and nine other spines on the external margin, internal margin with ten spines.

*Type of the genus.*—*Coryacris diversipes*, new species.

*CORYACRIS DIVERSIPES*, new species.

*Types.*—Male and female; Corumbá, Matto Grosso, Brazil. Female in March on highland. (H. H. Smith.) Cat. No. 12081, U.S.N.M.

Size large; form rather slender in the male, slightly more robust in the female; surface of the pronotum and pleura impresso-punctate. Head with its dorsal length slightly more than half the dorsal length of the pronotum in the male, two-fifths the length of the same in the female; occiput very slightly arcuate, descending slightly in the interocular region, which is equal in width to about three-fourths that of the fastigium; surface of the fastigium subhorizontal, the lateral margins subarcuate when seen from the sides, when seen from the dorsum the apex of the fastigium is seen to be acute-angulate, the margins slightly bowed in both sexes and slightly blunter and the angle broader in the female than in the male, fastigio-facial junction rounded in the female but with a slight angle in the male, the line of the face distinctly but not greatly retreating in both sexes, more pronounced, however, in the male than in the female; frontal costa rather narrow, uniform,

<sup>a</sup> *Κορυς*, signifying *helmet*; *ακρίς*, signifying *locust*.

subequal in width except for a slight infra-ocular constriction in the male, sulcate throughout its length; lateral facial carinæ marked, slightly diverging ventrad in the male, decidedly arcuate divergent ventrad in the female; eyes quite prominent in the male, much less pronounced in the female, subovate, in length distinctly exceeding the infra-ocular portion of the genæ in the male, slightly exceeding the same in the female; antennæ slightly more than twice the length of the dorsum of the pronotum, joints moderately elongate, proximal joints slightly depressed, in consequence giving a faint subensiform appearance to the appendage. Pronotum with the greatest dorsal width contained one and one-half times in the length; cephalic margin of the disk with a broad and very blunt obtuse angulation, caudal margin obtuse-angulate in both sexes, the immediate angle having a distinct, though small, rounded emargination; median carina distinct, subequal in the male, slightly arcuate on the prozona in the female; disk of the metazona flattened,



FIG. 1.—*CORYACRIS DIVERSIPES*. LATERAL VIEW OF MALE TYPE. ( $\times 14$ )

of the prozona rounding into the lateral lobes, caudal transverse sulcus strongly impressed, the two cephalic transverse sulci marked but not cutting such a pronounced gap in the median carina as the caudal one; prozona and metazona subequal in length, the prozona very slightly longer in the male; lateral angles very distinct, parallel, and horizontal on the metazona, descending on the prozona in a curve to the ventro-cephalic angle, this portion of the lateral angles being much more pronounced in the male than in the female; lateral lobes with their dorsal length very greatly exceeding their depth, ventral margin sinuate obtuse-angulate, ventral angles rounded obtuse. Tegmina about three and a half (female) to four (male) times the length of the dorsum of the pronotum, acute lanceolate, the costal lobe more pronounced in the female than in the male, the distal fourth of the costal margin gently rounding to the acute apex, sutural margin straight with a slight oblique truncation near the apex; intercalary area irregularly reticulate. Wings very slightly shorter than the tegmina when in repose. Prosternal spine distinctly



compressed, slightly bulbous in the apical half, this being more pronounced in the female than in the male, retrorse, apex rather blunt; interspace between the mesosternal lobes strongly longitudinal in both sexes, that between the mesosternal lobes as broad as long and contracted caudad in the male, slightly transverse in the female. Supra-anal plate of the male acute-angulate, the margins slightly constricted halfway to the apex, a deeply impressed area like the inverted upper portion of an exclamation mark present proximomesad; cerci simple, styliform, very short; subgenital plate moderately full at the base, decidedly compressed distad, this portion being somewhat rostrate, strongly keeled dorsad, distinctly so ventrad, and narrowly rounded acute angulate when seen from the side, the sides of the body of the plate provided with a longitudinal cariniform fold extending two-thirds the length of the plate. Ovipositor jaws of the female robust, blunt, the margins of the dorsal pair not serrate. Cephalic and median limbs rather robust, the femora distinctly inflated in the male. Caudal femora about two-thirds the length of the tegmina, rather slender, tapering, carinæ unarmed except for a slight serrulation on the dorsal carina of the male, pagina with a moderately regular but poorly impressed pattern, genicular lobes strongly rounded; caudal tibiæ slightly shorter than the femora, spines of the internal margin longer than those of the external and both series ten in number.

General color in the female dull walnut brown, this shade covering the head, greater part of the pronotum and pleura, while in the male the pleura alone are colored with it. Tegmina bice green in both sexes, sprinkled with a number of minute olive spots near the apex. Cephalic and median limbs dull bice green in the male, very dull olive-green in the female, the femora in both sexes with rows of whitish spots and a median line of purplish lead color. Caudal femora buff-yellow in both sexes, the internal face with a number of oil green blotches along the carinæ, very distinct in the male, much less distinct and sub-obsolete in the female, carinæ of the lateral face with a number of very faint small green points, genicular arches and base of the lobes blackish brown; caudal tibiæ with the external face greenish yellow, marked at the base of each spine with bice green, dorsal face bice green, internal face yellowish with a green blotch at the base of each spine, the distal half of the internal margin lined with scarlet, the internal aspect of the tarsi colored with the same, spines blackish at the apex, the proximal halves of those on the external margin yellowish externally, greenish internally, those on the internal

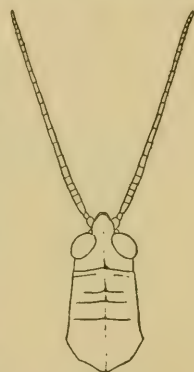


FIG. 2.—*CORYACRIS* *DIVERSIPES*. DORSAL OUTLINE OF HEAD AND PRONOTUM. ( $\times 1\frac{1}{2}$ )



margin washed with greenish, the colors on the tibiae in the female being similar to those described above from the male but weaker and less sharply contrasted. Head of the male isabella color, the caudal portion of the genae maize yellow; margins of the costa drab, eyes tawny-olive; antennae becoming madder brown distad. Pronotum of the male saffron yellow in the middle of the dorsum, shading laterad to seal brown, this latter being ventrad of the lateral angles, a narrow area along the cephalic portion of the angles, some of the caudal margin of the lobes and a large patch covering the ventro-caudal portion of the lateral lobes maize yellow. This yellowish area is represented in the female by a narrow edging to the caudal margin of the lobes and a broken dull patch along the ventral portion of the same.

Measurements.

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	40	59
Length of pronotum.....	8.5	13.5
Length of tegmen.....	37.5	49
Length of caudal femur.....	24.5	33.5

A female labeled Cuyaba, Matto Grosso, February, has also been examined. It is distinctly smaller than the female type with the area between the mesosternal lobes less strongly longitudinal, the caudal margin of the disk of the pronotum without the median emargination and the general color of the tegmina brighter.

Genus *ÆOLACRIS* Scudder.

1875. *Æolacris* SCUDDER, Proc. Boston Soc. Nat. Hist., XVII, p. 269.

*Type*.—*Xiphicera octomaculata* Scudder.

*ÆOLACRIS BELLA*, new species.

*Type*.—Male; Rio Purus, Brazil. March 15, 1901. (J. B. Steere.)  
Cat. No. 12082, U.S.N.M.

Closely allied to *Æolacris octomaculata* Scudder from Napo or Marañon,<sup>a</sup> but differing in the larger size, shorter fastigium, the distinct and nonconfluent tegminal spots, the longer spines on the caudal tibiae and the coloration of the antennae. No close relationship exists with *Æolacris caternaulti* Feisthamel from Cayenne, the remaining species of the genus.

Size large; form very considerably compressed; surface of the pronotum, pleura, venter and abdomen impresso-punctate. Head with the visible dorsal length very slightly more than half that of the pronotum; occiput subhorizontal, the interocular region broad,

<sup>a</sup> Proc. Bost. Soc. Nat. Hist., XII, p. 337.

being equal to two-thirds the fastigial length; fastigium prominent, slightly ascending, the dorsal length equal to the exposed portion of the occiput, when seen from the dorsum evenly tapering to near the apex which is very bluntly rounded, a distinct medio-longitudinal depression present in the distal half, when seen from the side the angle of the fastigium is acute-angulate with the immediate angle narrowly rounded; face strongly retreating to the ocellus, thence very slightly so; frontal costa continuous, distinct; sulcate throughout its length, greatly compressed at its junction with the fastigium, thence very gradually widening to the clypeal suture; lateral facial carinae very prominent, slightly diverging ventrad; eyes very prominent, large, ovate in outline, the length about equal to that of the infra-ocular portion of the genae; antennae about twice the length of the head and pronotum, joints elongate, strongly depressed proximad and decidedly ensiform, tapering to the slender



FIG. 3.—*ÆOLACRIS BELLA*. LATERAL VIEW OF TYPE. (X 1)

and moderately acute apex. Pronotum with the greatest dorsal width contained about twice in the length; cephalic margin arcuato-emarginate, caudal margin acute-angulate; median carina represented by a thread-like trace, the dorsum with a slight depression on the cephalic portion of the metazona, lateral angles inflated and covered with numerous blunt spiniform tubercles, the tubercles being present on the entire length of the angles but the distinctly inflated character is limited to the metazona; lateral lobes with the greatest length distinctly exceeding the depth, ventral angles obtuse, ventral margin broadly rounded obtuse-angulate, the prozonal portion of the lobes with a diagonal blunt ridge extending ventro-cephalad to the ventro-cephalic angle, ending in a small blunt tubercle. Tegmina exceeding the apex of the subgenital plate by about the length of the pronotum, elongate, subequal, the greatest width contained about five and one-half times in the length; costal margin distinctly

arcuate proximad and distad, the median portion very slightly arcuate, sutural margin straight, apex obliquely truncate with the angles narrowly (costal) or broadly (sutural) rounded; anal area very narrow. Wings large, the greatest width contained about one and four-fifths in the length; costal margin straight except for the distal third which is considerably arcuate, apex slightly acute-angulate with the immediate apex rounded, margin of the axillary lobe produced and rounded; posterior axillary area inflated, fenestrate, the cross veins regular, oblique proximad, becoming straighter distad; greater portion of the median area sub-fenestrate, the "panes" subquadrate, translucent and not hyaline as in the axillary area. Prosternal spine erect, slender, acute, the immediate apex rather blunt. Mesosternal lobes separated by a slightly longitudinal interspace which is somewhat narrower than one



FIG. 4. AEO-LACRIS BELLA. DORSAL OUTLINE OF HEAD AND PRONOTUM OF TYPE. (X 1)

of the lobes; interspace between the metasternal lobes shallow, transverse, slightly broader than that between the mesosternal lobes. Abdomen compressed, the dorsum somewhat carinate; supra-anal plate acute trigonal with a deep, high margined medio-longitudinal impression; cerci short, simple, styliform; subgenital plate compressed, greatly produced, the apex being developed into an elongate spiniform process, medio-ventral section of the plate with an irregular carina. Cephalic and median limbs rather slender. Caudal femora about three-fifths the length of the tegmina, quite slender, tapering, genicular region rather large, genicular lobes rounded, prominent, pagina with a rather irregular "herring-bone" pattern, carina, particularly the dorsal one, weakly serrato-dentate; caudal tibiae almost equaling the femora in length, rather robust proximad and supplied with two compressed, lamellate, apically spiniform processes, lateral margin with seven short spines, one of which is

apical, internal margin with the same number, the spines being very long, as long as the lamellate processes, proximad, slightly curved, decreasing in length distad, the terminal one being very small.

General color olive green, washed on the median and costal portions of the tegmina with very dull and faint wine purple. Head and pronotum with a gradually expanding medio-longitudinal bar of ochraceous-buff on the dorsum; margins of the fastigium, dorsad and caudad of the eyes and the lateral angles of the disk of the pronotum blackish brown; face ochraceous, the carinae lined with brown; a diagonal bar of dull buff extends ventro-cephalad over a portion of the prozonal area of the lateral lobes and the caudal portion of the genae, remainder of the lateral lobes with a broad diagonal subequal bar of olive extending ventro-cephalad, ventro-



caudal section dull buff; eyes burnt umber; antennæ blackish, tipped with naples yellow. Pleura very dull buff, margined dorsad by a diagonal bar of blackish, the area immediately cephalad of the insertion of the median limbs of the same color. Tegmina with the anal area chromium green, the series of ocelliform spots found in this genus being in this species four in number, placed near the principal veins—numbering proximo-distad the first is subcircular and entirely on the costal side, the second is of similar form and slightly on the veins, the third is roughly ovate and with the greater portion on the discoidal field, the fourth is elongate elliptical or sub-linear and entirely discoidal, only touching the veins, the color of the spots is deep chrome, edged with blackish brown; anal vein very dark brown. Wings with disk cadmium yellow, becoming cadmium orange toward the periphery, fenestrate axillary area clear hyaline; marginal color blackish brown, the width of the band being about a third the length of the wing at the apex and gradually narrowing proximad to the merest edging. Abdomen and venter wood brown, the former becoming cinnamon-rufous toward the apex. Cephalic limbs olivaceous, tarsi dull red brown; median limbs vinaceous rufous. Caudal femora very dull bottle green, the genicular arches and lobes dull blackish brown; cuadal tibiæ very dull liver brown, the spines orange-rufous touched with black.

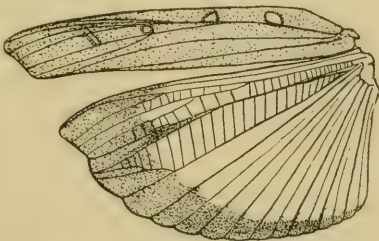


FIG. 5. —ÆOLACRIS BELLA. TEGMEN AND WING (X 1)

Measurements.

	mm.
Length of body.....	49
Length of pronotum .....	11.5
Greatest dorsal width of pronotum.....	6
Length of tegmen .....	45.5
Greatest width of tegmen .....	8.1
Length of caudal femur.....	27.6

A paratype male has also been examined. It is slightly smaller than the type, while the inflation of the lateral angles of the pronotum is less pronounced. The color is more decidedly green and the yellows are purer with less of orange and buff in them.

Genus PRIONOLOPHA Stål.

PRIONOLOPHA SERRATA (Linnæus).

Surinam. (C. J. Hering.) Four females. Pará, State of Pará, Brazil. August. (H. H. Smith.) One male. Corumbá, Matto Grosso, Brazil. March (1), April (1). Highland (1). (H. H. Smith.) Two males, two females.



## Genus TROPINOTUS Serville.

## TROPINOTUS ANGULATUS Stål.

1873. *T[ropinotus] angulatus* STÅL, Öfv. Kong. Vet.-Akad. Förh., 1873, no. 4, p. 53. [Bahia.]

Bonito, Pernambuco, Brazil. February, 1880. (A. Koebele; collected on cotton.) One female. Chapada, Matto Grosso, Brazil. April (2). (H. H. Smith.) One male, two females. Corumbá, Matto Grosso, Brazil. March, highland. One female.

These specimens vary considerably in the length of the tegmina and wings, but all agree in the distinct angles to the lateral carinæ of the pronotum. The maculations of the tegmina are also variable in intensity and correspondingly in the presence or absence of those weakly indicated in the more varied form. In one specimen the proximal band alone is indicated distinctly and that by two maculations, a larger one in the discoidal area and a smaller one in the projection of the costal area. The distal bands are very faintly indicated in this specimen and chiefly by infuscations along the sutural margin.

## TROPINOTUS ATTENUATUS, new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. September. (H. H. Smith.) Cat. No. 12083, U.S.N.M.

Closely allied to *T. gracilis* Bruner with a topotypic male of which the new species has been compared,<sup>a</sup> and from which it differs in the slightly greater size, the more distinctly sulcate frontal costa, the shorter and blunter subgenital plate and in the lesser number of spines (twelve to fourteen) on the margins of the caudal tibiæ.

Size medium; form elongate, very slender. Head with its dorsal length contained slightly more (male) or less (female) than three times in the dorsal length of the pronotum; occiput very slightly arcuate, fastigium horizontal, a distinct median carina present on both; angles of the fastigium slightly acute, the margin slightly elevated, interspace between the eyes very slightly less than the greatest fastigial width; fastigio-facial angle moderately rounded, the face considerably retreating; frontal costa narrowed dorsad, subequal from between the antennæ to the clypeal suture in the male, very slightly expanding in the female, slightly but appreciably constricted at the ocellus, sulcate from between the antennæ to ventrad of the ocellus; lateral facial carinæ prominent, considerably diverging ventrad; eyes ovate, not very prominent, in length somewhat exceeding that of the infra-ocular portion of the genæ; antennæ about equal in length to the head and pronotum, depressed, sub-ensiform. Pronotum with the greatest width contained, more than twice in the

<sup>a</sup> São Paulo, Brazil, Sept. 14, 1900 (Hempel).

length; cephalic margin of the disk obtuse-angulate with the sides of the angles slightly arcuato-emarginate, caudal margin acute-angulate, very sharp in the male; median carina moderately elevated, gently arcuate cephalo-caudad in the female, in the male with the highest point at the middle of the metazona from which the



FIG. 6.—*TROPINOTUS ATTENUATUS*. LATERAL VIEW OF FEMALE TYPE. ( $\times 1\frac{1}{2}$ )

carina very gradually slopes cephalad and caudad, the three transverse sulci hardly breaking the line of the carina, metazona half again as long as the prozona; lateral angles very distinct, regularly but not greatly diverging caudad; lateral lobes with the dorsal length slightly greater than the depth, ventro-cephalic angle obtuse, ventro-caudal angle rounded rectangulate. Tegmina exceeding the apices of the

abdomen and of the caudal femora, about two and two-thirds times the length of the dorsum of the pronotum, rather narrow; costal lobe distinct, well rounded, remainder of the costal margin straight except toward the apex, where it is considerably arcuate, sutural margin straight, the apex narrowly rounded. Prosternal spine strongly compressed, decidedly retrorse at the apex, the tip slightly blunt; interspace between the mesosternal lobes narrow, decidedly longitudinal; interspace between the metasternal lobes small, slightly longitudinal in the male, subquadrate in the female. Subgenital plate of the male acute, compressed, with a slight ventral carina. Cephalic and median limbs slender. Caudal femora one and three-fourths (female) to one and four-fifths (male) times the length of the dorsum of the pronotum, rather slender, dorsal and ventral carina serrulate, pagina with the pattern moderately regular, genicular lobes acute; caudal tibiae distinctly but not greatly shorter than the femora, armed on the external margin with thirteen to fifteen spines, one of



FIG. 7.—*TROPINOTUS ATTENUATUS*. DORSAL OUTLINE OF HEAD AND PRONOTUM. ( $\times 1\frac{1}{2}$ )

which is apical, on the internal margin with twelve to thirteen spines, those of the internal margin being longer than those on the external margin and slightly curved.

General color ochraceous in the male, clay color in the female. Male with the dorsum of the pronotum and anal and discoidal fields

of the tegmina chestnut, blackish on the sides of the disk and along the principal group of tegminal veins; costal field of the tegmina pale oil green edged along the principal veins with a narrow line of buff. Female with the median portion of the disk of the pronotum cinnamon, sides of the same broccoli brown, the dividing line an irregular one of bistre; anal and costal areas of the tegmina, aside from a pale buff humeral line, prout's brown, the discoidal field pale cinnamon, clouded along the costal portion with prout's brown blotchings. A faint medio-longitudinal head stripe and equally faint postocular bars are present in both sexes; antennæ vandyke brown, narrowly edged with buff proximad, the distal half entirely russet in the male; eyes prout's brown in the male, tawny-olive in the female. Lateral angles of the pronotum edged ventrad with bistre (female) or vandyke brown (male), a faint longitudinal line of the same color crossing the lateral lobes slightly dorsad of the middle; crest edged with naples yellow. Tegmina with the distal two-thirds of the sutural margin weakly blotched with prout's brown, the discoidal and median veins with fine buffy dashes along their proximal portions. Venter pale ochraceous, the abdomen the same in the female, wood brown in the male with the segments edged and lined with blackish. Cephalic and median limbs of the general color somewhat lined and mottled with darker. Caudal femora of the general color suffused along the dorso-median and dorso-lateral carinæ and along the center of the pagina with prout's brown, genicular lobes the same; caudal tibiæ raw sienna in the male, dark clay color in the female, spines yellowish tipped with black.

*Measurements.*

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	33.4	40
Length of pronotum.....	10.5	12.5
Length of tegmen.....	30.5	36.5
Length of caudal femur.....	19.5	22.7

A paratypic male taken in June and two paratypic females taken in July and September have been examined in addition to the types. In size these specimens agree very well with the type pair, but in color the tendency found in this genus to vary along certain lines is well exhibited. The July female has the lateral portions of the disk of the pronotum and costal area of the tegmina green, while the remainder of the dorsum is quite light. The paratypic September female has the green much the same but darker, while the rich ochraceous discoidal field is contrasted with the very dark brown anal field and humeral region. The additional male is colored much as the type female, but has the costal area green.



## Genus COLPOLOPHA Stål.

## COLPOLOPHA OBSOLETA (Serville).

1831. *Tropinotus obsoletus* SERVILLE, Ann. Sci. Nat., XXII, p. 274. ["Cap de Bonne-Espérance."]

Santarem, State of Para, Brazil. (H. H. Smith.) One male.

This specimen has been compared with an authentic female specimen from Cayenne received from the late Doctor Saussure.

Genus HELIONOTUS,<sup>a</sup> new.

Allied to *Draconata* Pictet and Saussure<sup>b</sup> from Colombia, but differing in the prozona being shorter than the metazona, the antennæ being twenty-one jointed, the tegmina attingent dorsad, the subgenital plate of the male acute, the caudal femora distinctly spinose on the dorsal carina. It is immediately separated from *Colpolopha* Stål by the strongly spinose lateral margins of the pronotum.

Fastigium with the dorsum horizontal, not sulcate; frontal costa precurrent, constricted ventrad of the ocellus where the line of the face is slightly angulate; antennæ twenty-one jointed. Pronotum with the median carina cristate, ascending to the middle of the metazona, caudal section of the same acute spiniform; transverse sulci three in number, all deeply severing the median carina; lateral angles strongly tuberculate (female) or acute spiniform (male), projecting laterad. Tegmina very short, attingent (male) or overlapping (female), costal lobe very greatly developed; apex narrow, sinuato-truncate. Ovipositor jaws of female very blunt. Subgenital plate compressed, the tip rostrate. Caudal limbs with the angles and dorsal surfaces serrato-dentate; caudal tibiæ somewhat sinuate, external margin armed with nine or ten spines including the apical spine, internal margin with nine spines.

Type.—*Helionotus mirabilis*, new species.

## HELIONOTUS MIRABILIS, new species.

Types.—Male and female. Bonito, Pernambuco, Brazil. January, 1883. (A. Koebele.) Cat. No. 12084, U.S.N.M.

Size medium (male) to large (female); form slightly compressed, moderately slender in the male, obese and fusiform in the female; surface of the thorax, except the venter, impresso-punctate, head and abdomen much smoother. Head with the dorsum a third (male) or less than a third (female) the length of the pronotum; occiput slightly arcuate, a very faint medio-longitudinal carina present; fastigium horizontal, blunt lanceolate in the male when seen from the dorsum, subtrigonal in the female, lateral margins slightly arcuate

<sup>a</sup> ἥλιος, signifying sun; voros, signifying back.

<sup>b</sup> Mitth. Schweiz. Ent. Ges., VII., p. 341.



when seen from the side, the disk of the fastigium slightly depressed near the apex; interspace between the eyes equal to the greatest width of the fastigium; fastigio-facial angle rather narrowly rounded,

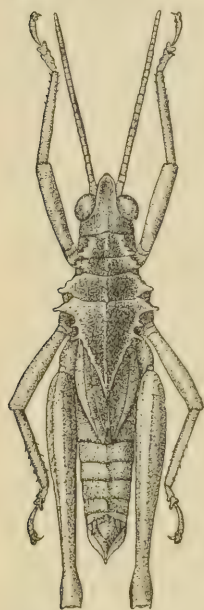


FIG. 8. *HELIONOTUS MIRABILIS*. DORSAL VIEW OF MALE TYPE. (X2)

the line considerably (male) or very slightly (female) retreating, a slight angle between the line of the face and the line of the fastigium; frontal costa distinct, narrow and subequal from the apical constriction to immediately ventrad of the ocellus, where there is a decided constriction, thence the margins diverge slightly (male) or considerably (female) to the clypeal suture, the costa distinctly but shallowly sulcate throughout its length; supplementary facial carinae distinct, following in their direction, but in a more pronounced manner, the trend of the costal margins; eyes decidedly (male) or moderately (female) prominent, ovate in outline, in length slightly longer than (male) or distinctly shorter than (female) the infra-ocular portion of the genae; antennae slightly exceeding the length of the head and pronotum in the male, somewhat depressed proximad. Pronotum with the disk flattened, rising mesad to the crest, the greatest width of the dorsum contained about one and one-half times in the length; cephalic

margin obtuse-angulate in the male, with an almost imperceptible angle in the female, caudal margin produced acute-angulate in both sexes, the apical spines very sharp; median carina elevated into a serrate crest, which gradually increases in elevation to the middle of the metazona, thence sharply descends, the crest being severed by the three transversesulci, the incisions being marked in both sexes, but extending half-way to the level of the disk with the intermediate portions acute



FIG. 9. *HELIONOTUS MIRABILIS*. LATERAL VIEW OF MALE TYPE. (X2)

dentiform in the male, the metazonal portion armed on the descending slope with long dentiform spines similar to those seen in species of *Colpolopha*; lateral angles projecting laterad and regularly armed with numerous blunt denticles in the female and with a series of very prominent elongate spini-

form processes in the male; the dorsum of the pronotum is distinctly diamond-shaped, regularly narrowing cephalad and caudad, but more sharply so caudad; surface of the dorsum with a number of rather regularly placed raised points; lateral lobes with their dorsal length distinctly greater than their depth. Tegmina about two-thirds the length of the dorsum of the pronotum, coriaceous, the principal veins alone marked; costal lobe greatly developed, the costal field at the middle of the tegmen being wider than the remainder of the same, costal margin concavely emarginate from the greatly developed but rounded lobe to the apex; costal angle of the apex acute; sutural margin slightly arcuate; apex narrow, obliquely and very decidedly sinuato-truncate. Wings reaching very nearly to the apex of the tegmina. Prosternal spine conic, erect, acute, interspace between the mesosternal lobes subquadrate in the male, slightly transverse in the female; interspace between the metasternal lobes transverse and slightly broader than the mesosternal interspace in both sexes. Abdomen slightly compressed in both sexes, the dorsum distinctly keeled and provided with spiniform points which are distinct in the male, almost obsolete on the exposed segments in the fe-



FIG. 10. *HELIONOTUS MIRABILIS*. LATERAL VIEW OF FEMALE TYPE. ( $\times 1\frac{1}{2}$ )

male; supra-anal plate of the male trigonal, cerci simple, acute styli-form, subgenital plate acute rostrate, distinctly carinate ventrad; ovipositor jaws of the female very blunt, margins hardly toothed. Cephalic and median femora somewhat inflated in the male, slenderer in the female. Caudal femora about as long as from the apex of the fastigium to the apex of the tegmina, robust proximad, slender distad, pagina with the pattern somewhat irregular and subimbricate, medio-dorsal carina acute serrato-dentate, the serrations numerous and of two grades, ventral carinae similar but with the serrations less numerous, of equal size in the male, smaller in the female, lateral carinae with blunter and shorter denticles, genicular lobes acute; caudal tibiae slightly shorter than the femora, sinuate, spines of the internal margin slightly longer than those of the external.

General colors of the male broccoli and hair brown; face cinnamon, the antennae isabelline, tips of the processes of the crest and lateral angles of the pronotum cinnamon, which color is also present as a

blotch along the ventral margin of the lateral lobes and obliquely across the middle of the same; eyes burnt umber; tegmina with a blackish brown spot, subovate in the male, subcircular in the female, on the ventral surface of the costal field, showing through on the dorsum, median section of the male tegmen with a longitudinal bar of cinnamon; limbs dull ochraceous with a trace of olivaceous, spotted with blackish; caudal tibiæ dirty olive-green, the spines narrowly tipped with black.

General color of the female walnut brown, the abdomen burnt umber clouded with seal brown, the caudal limbs with russet the general color, while the tegmina are distinctly liver brown; points of the pronotal spines yellowish, the tegmina with the costal spot as apparent as in the male.

*Measurements.*

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	25.5	39
Length of pronotum.....	10.8	15
Greatest width of dorsum of pronotum.....	6.5	10.5
Length of tegmen.....	6.8	11
Length of caudal femur.....	16.3	23.5

A paratype pair have been examined in addition to the types, the data on both being to the effect that they were collected "on cotton." They agree fully with the types in structure, differing only in the general shade of color.

Genus *ELÆOCHLORA* Stål.

*ELÆOCHLORA TRILINEATA* (Serville).

1831. *Xiphocera trilineata* SERVILLE, Ann. Sci. Nat., XXII, p. 272. [Brazil.]

Rio de Janeiro, Brazil. December. (H. H. Smith.) One male.

The general color of this specimen is very deep green, the median stripe on the head and pronotum also being more ochraceous than the buffy margins of the tegmina.

*ELÆOCHLORA HUMILIS*, new species.

*Type*.—Male. Chapada, Matto Grosso, Brazil. (H. H. Smith.) Cat. No. 12085, U.S.N.M.

Allied to *Elæochlora viridicata* (Serville), but differing in the weaker and lower median carina of the pronotum, the more prominent eyes and the narrower tegmina.

Size rather large; form moderately slender; surface of the body as usual in this genus. Head with its exposed dorsal length less than half the length of the dorsum of the pronotum; occiput very slightly arcuate; fastigium subhorizontal, a shallow medio-longitudinal depression present cephalad, form of fastigium acute-angulate,



the apex very narrowly rounded, margins very slightly elevated; facio-fastigial angle narrowly rounded when seen from the side, face moderately retreating; frontal costa very gradually widening ventrad from its junction with the fastigium to immediately ventrad of

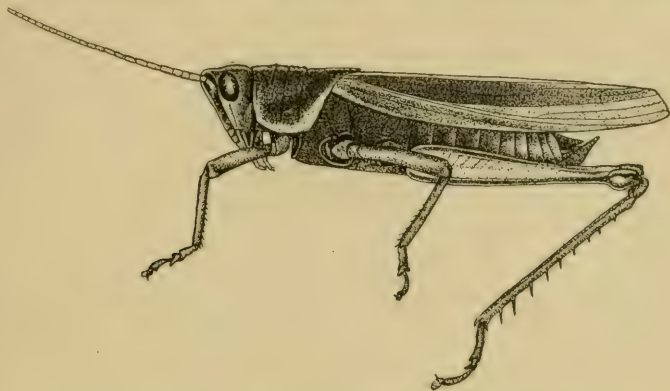


FIG. 11.—*ELEOCHLORA HUMILIS*. LATERAL VIEW OF TYPE. ( $\times 1\frac{1}{2}$ )

the insertion of the antennæ, subequal thence to the clypeal suture except for a slight constriction ventrad of the ocellus, sulcate throughout its length; supplementary facial carinæ prominent, slightly divergent caudad; eyes quite prominent when seen from the dorsum, ovate in outline, in length very slightly exceeding the infra-ocular portion of the genæ; antennæ slightly longer than the caudal femora, acute, slightly depressed proximad. Pronotum with the disk flattened caudad, slightly tectate cephalad; cephalic margin very slightly angulate, caudal margin slightly acute-angulate, the apex sharp; median carina low, not elevated; lateral angles subparallel in the metazona, the diverted ridge on the lobes of the prozona with fair sized tubercles, greatest dorsal width of the disk slightly more than half the length of the same; transverse sulci three in number, metazona very slightly longer than the prozona; lateral lobes with the ventral margin arcuate, ventro-cephalic angle rounded obtuse, ventro-caudal angle obtuse. Tegmina about two and one-half times the dorsal length of the pronotum, sublanceolate, the greatest width of the tegmen contained about five and one-half times in the length of the same; costal margin nearly straight mesad, slightly arcuate proximad and distad, sutural margin nearly straight, apex obliquely rotundato-truncate. Wings reaching to the apex of the tegmina. Prosternal spine conic, rather blunt, very slightly retrorse; interspace between the mesosternal lobes subquadrate, the angle of the lobes very broadly rounded; interspace between the metasternal



FIG. 12.—*ELEOCHLORA HUMILIS*. DORSAL OUTLINE OF HEAD AND PRONOTUM OF TYPE. ( $\times 1\frac{1}{2}$ )



lobes distinctly transverse. Abdomen slightly compressed, supra-anal plate acute trigonal, the apex quite sharp and appreciably decurved, medio-longitudinal sulcus distinct; cerci very small, simple, styliform; subgenital plate compressed, the apex produced, acute rostrate, the ventral line of the produced portion carinate. Cephalic and median limbs of moderate size, the femora slightly inflated. Caudal femora about twice the length of the dorsum of the pronotum, moderately slender, regularly tapering, pattern of the pagina regular; caudal tibiae about equal to the femora in length, almost imperceptibly sinuate, spines on external margin ten in number including the apical one, spines on the internal margin numbering the same.

Color pattern similar to that of males of all the species of the genus. Color on the sides of the dorsum of the pronotum, margining the median stripe on the head and covering the median section of the tegmina blackish, the median stripe on the head, pronotum, and anal area of tegmina tawny ochraceous. Costal area of the tegmina and that of the principal veins of the same pale oil green. Lateral lobes of the pronotum and sides of the head olive-green, the edging of the pronotal lobes, the line below the eye, and the proximo-costal streak on the tegmina buff. Eyes burnt umber; antennae walnut brown. Pleura very dark olive-green; abdomen and venter raw umber. Limbs pale oil green; the caudal femora slightly brownish; the caudal tibiae a brighter green, with the spines entirely black.

*Measurements.*

	mm.
Length of body .....	34
Length of pronotum .....	10
Length of tegmen .....	27.5
Length of caudal femur .....	19.8

The type alone has been seen.

*ELÆOCHLORA PULCHELLA*, new species.

*Type*.—Male. Corumbá, Matto Grosso, Brazil. (H. H. Smith.) Cat. No. 12086, U.S.N.M.

Allied to *Elæochlora viridicata* (Serville) and *E. humilis* Rehn, but differing from both in the tegmina and wings not reaching the apex of the abdomen and in the fastigium being somewhat depressed caudad and projecting so that the angle of the face is not straight, but slightly concave. In the weak median carina of the pronotum it agrees with *E. humilis*, but the coloration is more like *E. viridicata*.

Size medium; general form and surface similar to other species of the genus. Head with its exposed dorsal length slightly less than half that of the pronotum; occiput very considerably arcuate; the interocular area considerably depressed; fastigium moderately acute trigonal, the apex when seen from the dorsum very

narrowly rounded, the surface distinctly depressed within the margins; when seen from the side, the line of the fastigium rises very considerably from the interocular depression, rounding over the summit of the fastigium into the facial line; angle of the face con-

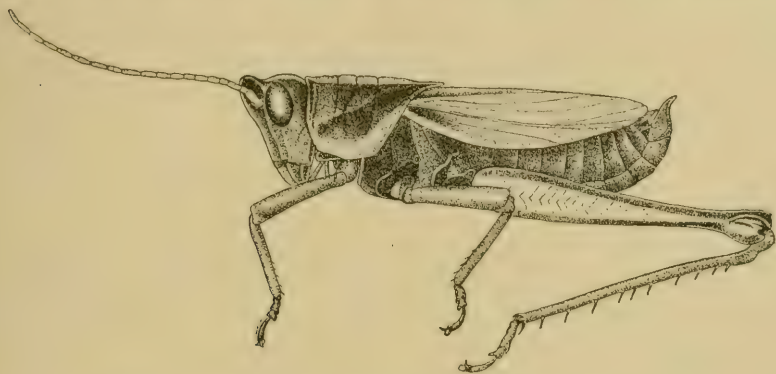


FIG. 13.—*ELEOCHLORA PULCHELLA*. LATERAL VIEW TYPE. ( $\times 2$ )

siderably retreating, slightly concave; frontal costa very slightly expanding caudad, reaching to the clypeal suture, sulcate throughout its length; eyes moderately prominent, ovate in outline, in length very slightly exceeding the infra-ocular portion of the genæ;

antennæ over twice the length of the pronotum, rather slender, very slightly depressed proximad. Pronotum with its greatest dorsal width contained one and five-eighths times in the length, slightly tectate on the prozona, distinctly flattened on the metazona; cephalic margin subtruncate, caudal margin rectangulate; median carina moderately elevated, with an extremely slight longitudinal arcuation; lateral angles rectangulate on the metazona, descending ventro-cephalad and armed with distinct tubercles on the prozona; transverse sulci three in number, deeply impressed, prozona and metazona subequal in length; lateral lobes very considerably longer than deep, the ventral margin obtuse-angulate, the caudal margin oblique, the ventro-caudal angle obtuse; all the pronotal margins except the ventral ones supplied with small, rounded, more or less distinct and regularly placed nodes. Tegmina very slightly longer than the head and pronotum together, reaching to the base of the supra-anal plate, acute-lanceolate in shape; costal margin arcuate, sutural margin straight.

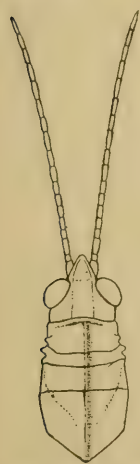


FIG. 14.—*ELEOCHLORA PULCHELLA*. DORSAL VIEW OF HEAD AND PRONOTUM OF TYPE. ( $\times 2$ )

Wings reaching to the tips of the tegmina. Prosternal spine erect, conic, slightly blunted; interspace between the mesosternal lobes very slightly longitudinal; interspace between the metasternal lobes slightly transverse, the cephalic margin of the same obtuse-angulate.

Abdomen slightly compressed; supra-anal plate acute trigonal, the apex blunt, the plate tectate in transverse section, the median section slightly elevated, gradually narrowing caudad; cerci very small, simple, styliform; subgenital plate compressed, produced rostrate, the apex slightly depressed, medio-ventral line carinate and slightly lamellate before the apex. Cephalic and median femora moderately inflated. Caudal femora slightly shorter than the head and tegmina together, moderately slender, tapering, the pagina with a rather regular pattern, genicular lobes with the apex narrowed and rounded; caudal tibiae about equal to the femora in length, armed in the external margin with 11 spines including the apical one, internal margin with 9 spines.

General color pattern that found in most species of the genus. Medio-longitudinal stripe orange-rufous on the head, orange-ochraceous on the pronotum, becoming paler caudad and cream buff on the anal area of the tegmina; remainder of disk of pronotum, sides of the dorsum of the head and along the anal vein of the tegmina blackish, the blackish extending over the lateral lobes of the pronotum and there washed with olive-green. Face gallstone yellow; genæ washed with olive-green; eyes burnt umber; antennæ olive, greenish proximo-ventrad; fastigium margined laterad with blackish. Pronotum with the deflected lateral angles greenish yellow, the usual pale blotch on the margins of the lateral lobes cream-buff. Tegmina pale oil green, margined on the costal edge with a bar of dull whitish, relieved proximad by an adjacent internal splotch of blackish. Abdomen tawny-olive. Femora vinaceous-cinnamon, oil green distad, genicular arches of caudal femora mars brown; caudal tibiae and tarsi oil green, the former with the spines on the internal margin blackish, on the external margin pale with blackish tips.

*Measurements.*

	mm.
Length of body .....	28
Length of pronotum .....	9
Length of tegmen .....	16
Length of caudal femur .....	19

The type is unique.

Genus *CALLONOTACRIS*,<sup>a</sup> new.

A member of the *Tænipodæ* and allied to *Tæniopoda*, from which it differs in the compressed form, in the strongly elevated and arcuate pronotal crest, and the slightly fossulate fastigium.

Form compressed; head very much deeper than broad; fastigium strongly declivent and very slightly fossulate; frontal costa continuous with the compressed frontal costa. Pronotum cristate, strongly

*Καλλος*, signifying *beauty*; *νωτος*, signifying *back*; *ακρίς*, signifying *grasshopper*.



arched cephalo-caudad, cephalic angle of the disk considerably produced, caudal angle very greatly produced. Tegmina ample in the male, rather short in the female; costal lobe well developed. Wings well developed; axillary area slightly inflated in the male. Caudal tibiae with the spines of the two margins subequal in length; apical spine present on the external margin.

The superficial resemblance of this genus to the *Ædipodine* genera *Tropidolophus* and *Pyrgodera* is considerable.

*Type*.—*Callonotacris lophophora*, new species.

CALLONOTACRIS LOPHOPHORA,<sup>a</sup> new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. January (female), April (male). (H. H. Smith.) Cat. No. 12087, U.S.N.M.

Size moderately large; surface of the head smooth, of the pronotum and pleura rugulose-punctate. Head with the exposed dorsal length

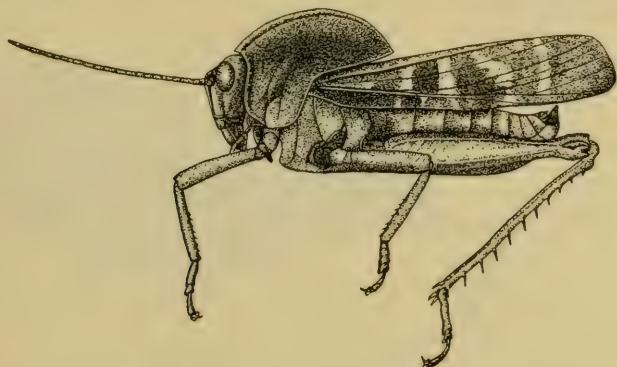


FIG. 15.—CALLONOTACRIS LOPHOPHORA. LATERAL VIEW OF MALE TYPE. ( $\times 1\frac{1}{2}$ )

equal to half (female) or two-thirds (male) the width across the eyes; occiput very slightly rounded, dipping sharply into the fossulate disk of the fastigium in the male, less sharply so in the female; disk of the fastigium moderate fossulate in the male, slightly so in the female, a very slightly raised margin surrounding the lateral and caudal borders of this area, in addition to which there is also a trace of a medio-longitudinal line of a similar structure, this latter being distinctly marked in the male and hardly appreciable in the female; cephalic portion of the fastigium with a slight medio-longitudinal sulcus, cephalic margins of the fastigium sharply compressed and passing ventrad as the lateral margins of the frontal costa; lateral foveolæ prominent, set in a subtrigonal area; fastigio-facial angle

<sup>a</sup>*Λοφος*, signifying *crest*; *φορα*, signifying *carrying*.



rounded obtuse-angulate, face hardly retreating, subvertical; frontal costa very narrow, subequal (female) or very slightly expanding (male) dorsad of the ocellus, slightly constricted ventrad of the ocellus, the margins diverging thence and becoming fainter until hardly appreciable at the clypeal suture, sulcate except in the ventral fourth; eyes moderately (male) or hardly (female) prominent, elongate subreniform-ovate in outline, slightly longer than (male) or equal (female) to the infra-ocular portion of the genæ; antennæ about equal to the caudal femora in length, simple, coarse, submoniliform distad. Pronotum with its dorsal length about four-fifths that of the caudal femora, the median carina elevated, cristate, arcuate, produced cephalad and caudad, the height of the crest from the dorsum being slightly more (male) or slightly less (female) than a fourth the length of the same, the margin of the crest entire; cephalic

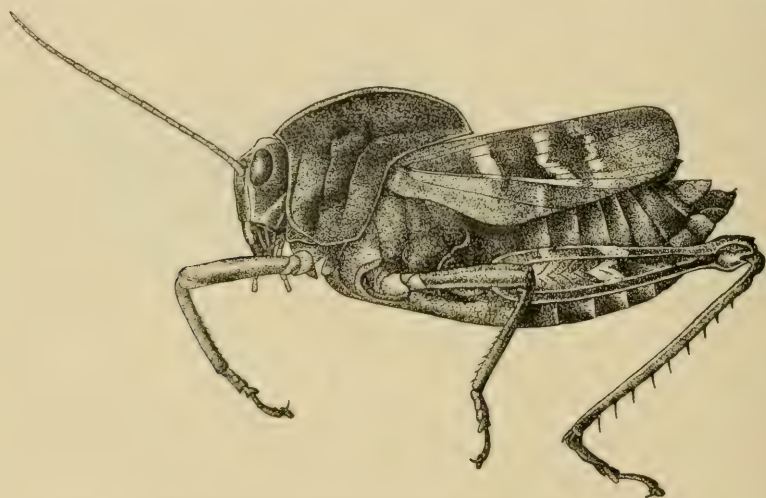


FIG. 16.—*CALLONOTACRIS LOPHOPHORA*. LATERAL VIEW OF FEMALE TYPE. ( $\times 1\frac{1}{2}$ )

margin produced rectangulate, caudal margin produced into a lanceolate process in length but little less than equal to the remainder of the pronotum; disk not at all flattened, sloping ventrad into the vertical lateral lobes, lateral angles but slightly developed on the metazona and these rounded; transverse sulci three in number, the principal one the deepest, none intersecting or even ascending the sides of the crest; lateral lobes with the dorsal length slightly greater than the depth, cephalic margin arcuate emarginate around the side of the head, ventral margin obtuse-angulate, caudal margin oblique, the ventro-caudal angle rounded obtuse-angulate. Tegmina about twice the length of the pronotum in the male, one and one-third times the length of the same in the female, broad in both sexes, the greatest width contained four and one-half (male) or two and one-third

(female) times in the length of the tegmen; costal lobe well developed, very large and more apparent in the female than in the male, sutural margin nearly straight, apex rotundato-truncate. Wings reaching to the tips of the tegmina, quite broad in the male, the axillary field with the margin arcuato-lobate, apex of the wing rotundato-truncate. Prosternal spine compressed, slightly retrorse, the apex caudad; interspace between the mesosternal lobes subquadrate in both sexes; interspace between the metasternal lobes transverse. Abdomen moderately compressed; supra-anal plate of the male acute-trigonal, tectate, the median sulcus narrow and not well marked; cerci of the male small, simple, styliform; subgenital plate compressed, slightly rostrate, the apex very acute when seen from the dorsum, moderately acute when seen from the side, ventral face of apex with a slight ridge; dorsal ovipositor jaws of the female with the edges unarmed. Cephalic and median limbs rather slender, moderately elongate. Caudal femora reaching to (female) or considerably exceeding (male) the apex of the abdomen, moderately compressed, moderately robust but tapering in the distal four-fifths and with a very slight dorsal concavity in the female, margins well elevated, pattern irregular; caudal tibiae equal to the femora in length, rather robust, very slightly sinuate, spines robust, ten (female) to eleven (male) in number on the external margin, eight in number on the internal.

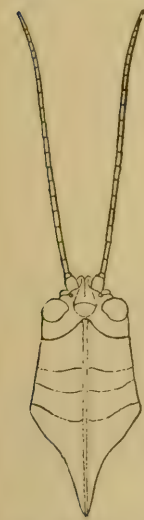


FIG. 18.—CALLO-NOTACRIS LOPHOPHORA. DORSAL OUTLINE OF HEAD AND PRONOTUM OF FEMALE TYPE. ( $\times 1\frac{1}{2}$ )



FIG. 17.—CALLO-NOTACRIS LOPHOPHORA. DORSAL OUTLINE OF HEAD AND PRONOTUM OF MALE TYPE. ( $\times 1\frac{1}{2}$ )

General color pitchy brown, lined along the crest with orange-ochraceous and marked on the interocular region and fastigium with the same color, bars of which cover the region along the supplementary facial carinae, reaching to the base of the labrum. Tegmina with obliquely transverse series of blotches of cream-buff, breaking up toward the margins and toward the apex. Caudal femora with three incomplete annuli of the same color; caudal tibiae orange-ochraceous, blackish distad and proximad, spines blackish at the bases and at the tips. Cephalic and median limbs blackish, with some obscure markings of dull cream-buff. Wings geranium red, margined with blackish, that of the anterior field broader than that of the remainder, disk with numbers of quadrate and oblong blotches of brownish black. Abdomen with the sides of the dorsal segments spotted along the edge with ochraceous-rufous, a large blotch of the same color at the dorsal

extremity of each ventral abdominal segment. Antennae tipped with buffy; eyes chestnut.

## Measurements.

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	32	44
Length of pronotum.....	13.5	18.2
Greatest dorsal width of pronotum.....	5.6	7.8
Length of tegmen.....	28.3	25.5
Length of caudal femur.....	18	23.5

A paratype pair have been examined in addition to the types. The only difference noticed is that the light markings on the tegmina and abdomen are more numerous and much more buffy in color.

## Genus ZONIOPODA Stål.

## ZONIOPODA MIMICULA, new species.

*Type*.—Male. Chapada, Matto Grosso, Brazil. November. (H. H. Smith.) Cat. No. 12088. U.S.N.M.

Closely allied to *Zoniopoda iheringi*; Pictet and Saussure, but differing in the smaller size, the narrower, subequal and less deflected



FIG. 19.—ZONIOPODA MIMICULA. LATERAL VIEW OF TYPE. (X2)

fastigium, the less angulate caudal margin of the pronotum and weaker median carina of the same. The subgenital plate is also somewhat more produced and the coloration more uniformly green.

Size rather small (for the genus); surface of head and thorax (except venter) punctate. Head with its dorsal length contained one and two-thirds times in that of the pronotum; occiput moderately elevated, arcuate, interocular region and fastigium slightly declivent, the former about two-thirds the greatest width of the fastigium; fastigium rectangulate with the apex truncate, lateral margins very slightly elevated, the surface of the disk ruguloso-punctate; fastigio-facial angle obtuse-angulate, facial line appreciably but not greatly retreating, slightly arcuate; frontal costa rather broad, subequal in width, very slightly narrowed at its junction with the fastigium, separated from the disk of the latter by a slightly elevated carina,



the margins of the costa hardly reaching the clypeal suture, punctate, with a trace of a median carina dorsad, distinctly sulcate for a short distance ventrad of the ocellus; supplementary facial carinae moderately divergent, convex arcuate; eyes moderately prominent, ovate in outline, in length exceeding the infraocular portion of the genae; antennae about twice as long as the pronotum. Pronotum with its greatest dorsal width contained about one and one-half times in the length; cephalic margin very slightly produced, arcuate, caudal margin obtuse-angulate; dorsum very slightly tectate, median carina hardly apparent on the prozona, distinct but very low on the metazona, lateral angles very well rounded, more apparent on the metazona than on the prozona; transverse sulci four in number, the cephalic not severing the carina, prozona and metazona subequal, dorsum of the metazona very slightly inflated; lateral lobes with the dorsal length slightly more than the depth, ventral margin rounded obtuse-angulate, ventro-caudal angle rather broadly rounded. Tegmina exceeding the tips of the caudal femora by nearly the dorsal length of the head, of medium width, costal margin with a slight indication of the costal lobe, sutural margin nearly straight, apical margin obliquely rotundato-truncate; principal veins rather heavy. Wings equaling the tegmina. Prosternal spine conic, erect, blunt; interspace between the mesosternal lobes reversed wedge-shaped, narrow cephalad, the caudal width about equal to the depth; interspace between the metasternal lobes small, subquadrate. Supra-anal plate lanceolate, the apex blunt, strongly tectate, the median sulcus broad proximad, narrower distad; cerci simple, styliform; subgenital plate very strongly produced, compressed, the apex with a narrow and deep V-shaped emargination, the line of the plate nearly straight and hardly elevated distad when seen from the side. Caudal femora reaching about to the apex of the abdomen, rather slender, pagina with a regular, close and obtuse-angulate pattern, genicular lobes slightly acute-angulate; caudal tibiae very slightly shorter than the femora, very slightly sinuate, armed on the external margin with ten to eleven spines, including the apical one, internal margin with eleven.

General color uniform pale apple green; eyes buff; antennae clove brown, the proximal segments annulate distad with yellowish; caudal tibiae and tarsi scarlet, the former greenish proximad, spines greenish, tipped with black.



FIG. 20.—ZONIO-  
PODA MIMIC-  
ULA. DORSAL  
OUTLINE OF  
HEAD AND PRO-  
NOTUM. (X 2)



## Measurements.

	mm.
Length of body.....	26.8
Length of pronotum.....	5.5
Length of tegmen.....	21.5
Length of caudal femur.....	14

A paratype male (October; in campo) has also been examined. It does not differ appreciably from the type.

## ZONIOPODA TARSATA (Serville).

1831. *Acridium tarsatum* SERVILLE, Ann. Sci. Nat., XXII, p. 283. [Brazil.]

Rio de Janeiro, Brazil. December. (H. H. Smith.) One male, one female.

These specimens are perfectly typical of the species, the cephalic and median femora being blackish with a broad median and a very narrow proximal incomplete annulus of red, the tibiae blackish with a median annulus of orange.

## Genus TROPIDACRIS Scudder.

1869. *Tropidacris* SCUDDER, Proc. Boston Soc. Nat. Hist., XII, p. 346.

Type, as here designated *T. dur* (Drury) [*Gryllus* (*Locusta*) *dur* Drury].

## TROPIDACRIS GRANDIS (Thunberg).

1824. *Gr[yllus] grandis* THUNBERG, Mém. Acad. Imp. Sci. St. Pétersbourg, IX, p. 403. [Locality not stated.]

Rio de Janeiro, Brazil. (H. H. Smith.) One male, one female. The uniform green tegmina are quite characteristic of this species.

## TROPIDACRIS CRISTATA (Linnaeus).

1758. [*Gryllus* (*Locusta*)] *cristatus* LINNÆUS, Syst. Nat., 10th ed., p. 431. [America; Arabia; Asia.]

Pará, Brazil. June. (H. H. Smith.) One male, three females.

Marajo, State of Pará, Brazil. February, 1901. (J. B. Steere.) One female.

Bonito, State of Pernambuco, Brazil. January 4 and February, 1883. (A. Koebele.) Two males, two females.

One Para male has the tegmina distinctly pinkish. Information with one of the Bonito individuals is to the effect that it was taken "on cotton."

## Genus LEPTYSMSA Stål.

## LEPTYSMSA OBSCURA (Thunberg).

Chapada, Matto Grosso, Brazil. August. September. (H. H. Smith.) Two males, three females.

Bonito, Pernambuco, Brazil. February 18, 1883. (A. Koebele.) One damaged individual, probably a male.

These specimens have the fastigium, as a rule, slightly smaller than Paraguayan specimens, while the variation in the form of the same is quite considerable.

Genus *LEPTYSMINA* Giglio-Tos.

1894. *Leptysmina* GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, IX, No. 184, p. 34.

Included *Leptysmina pallida* and *rosea* Giglio-Tos, of which the latter is here selected as the type.

*LEPTYSMINA ROSEA* (Giglio-Tos).

1894. *L[ep]tysmina* *rosea* GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, IX, No. 184, p. 34. [Buenos Ayres.]

Corumbá, Matto Grosso, Brazil. March; lowland. (H. H. Smith.)  
Five males.

These specimens are perfectly typical of this species, which is now known to range from Buenos Ayres to Corumbá.

In size the individuals in hand are very uniform. Specimens from Carcaraña, Argentina, determined as this species by Bruner, are seen on comparison with the descriptions and Corumbá material to be the allied *Leptysmina pallida* Giglio-Tos. The handiest index to the two species, aside from the greater size of *pallida*, is the character of the prosternal spine.

Genus *STENACRIS* Walker.

The species of *Stenacris* available for study may be separated by the following key:

- a. Subgenital plate of the male with either an erect dorsal median lobe or with the margin supplied with lateral acute processes or both.
- b. Subgenital plate of the male with a median dorsal lobation.
  - c. Fastigium moderately acute-angulate; eyes separated by an interspace about equal to one-third the greatest width of the fastigium; form as usual in the genus.....*S. cylindroides*.
  - c'. Fastigium very strongly acute-angulate; eyes separated by an interspace about equal to one-fourth the greatest width of the fastigium; form very slender.....*S. mexicana*.
- b'. Subgenital plate of the male with a pair of lateral horn-like processes, but no median erect lobule.....*S. vitreipennis*.<sup>a</sup>
- a'. Subgenital plate of the male produced and compressed, without accessory lobes or styles.
  - b. Size small (male 23-25 mm.); fastigium distinctly slender, slightly longer than broad.....*S. gracilis*.
  - b'. Size large (males 32-33, females 40-42 mm.); fastigium broad, at least as broad as long, in the female much broader than long.....*S. coccinipes*.

<sup>a</sup> This name will have to be used in place of *Stenacris chlorizans* Walker (*Arnilia chlorizans* of authors). Marshall's *Gryllus vitreipennis* (Zoologische Abhandlungen aus den Annalen des Wiener Museums der Naturgeschichte, 1841, p. 214, pl. xviii, fig. 6) described from Georgia is clearly the same insect as that to which Walker's name is now applied, agreeing in structure, color pattern, and size. In consequence the species must be known as *Stenacris vitreipennis* (Marshall).

## STENACRIS CYLINDRODES (Stål).

1860. *Opsomala cylindrodes* STÅL, Kong. Svenska Freg. Eugenies Resa, Ins., p. 325 [Rio Janeiro, Brazil].

Corumbá, Matto Grosso, Brazil. March; lowland. (H. H. Smith.) Three males, two females.

Bonito, State of Pernambuco, Brazil. January, 1883. (A. Koebele.) One male.

The Corumbá specimens are quite uniform in size and color, the pale lateral bar being visible in all, but quite weak in one female. The Bonito individual is distinctly smaller with the vertex blunter than is the case in the other representatives, but the genitalia are of exactly the same character.

This species is now known to range from the State of Pernambuco to that of Matto Grosso and the Chaco of Argentina (Resistencia).

## STENACRIS GRACILIS (Giglio-Tos).

1897. *A[rnalia] gracilis* GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, XII, No. 302, p. 30. [San Lorenzo, Jujuy, Argentina.]

Corumbá, Matto Grosso, Brazil. March; lowland. (H. H. Smith.) Three males.

These specimens are of much the same size, and have a dark dorsal edging to the lateral pale bar.

It is of interest to note that the genus *Leptysma* presents much the same types of male subgenital plate noticed in this genus, while at least one species of that genus has the pale lateral bar supplied with a darker edging as in this species.

The form is now known from the type locality, San Bernardino, Paraguay (Bruner) and Corumbá, Brazil.

## STENACRIS COCCINEIPES (Bruner).

Corumbá, Matto Grosso, Brazil. March; highland. (H. H. Smith.) One male, one female.

## Genus OXYBLEPTELLA Giglio-Tos.

## OXYBLEPTELLA PULCHELLA, new species.

*Types*.—Male and female; Chapada, Matto Grosso, Brazil. June. (H. H. Smith.) No. 12089. U.S.N.M.

Allied to *Oxybleptella sagitta* Giglio-Tos from Paraguay and São Paulo, Brazil, but more robust and less compressed, with the fastigium rectangulate (male) or obtuse angulate (female). The head is also somewhat inflated in the new form and the eyes are larger and more prominent.

Size small; form slender, subequal in width; surface glabrous, punctulate on the pronotum and pleura. Head with the exposed dorsal surface slightly longer than the dorsum of the pronotum; occiput with an extremely slight arcuation when seen from the side, very slightly elevated dorsad of the line of the pronotum, interocular region descending very slightly to the fastigium, the width of the interspace between the eyes about half that of the fastigium; fastigium slightly acute rectangulate (male) or slightly obtuse rectangulate (female), the apex broadly rounded, the breadth considerably greater than the length, disk of the fastigium slightly depresso-punctate within the margins, the interocular region (female) or interocular region and fastigium (male) with a slight but distinct medio-longitudinal sulcus; fastigio-facial angle acute-angulate, the immediate angle well rounded, facial line very strongly retreating, the angle of the face being even more decided ventrad of the insertion of the antennæ; frontal costa broad, considerably narrowed dorsad to meet the fastigium, subequal in width from between the antennæ to the clypeal

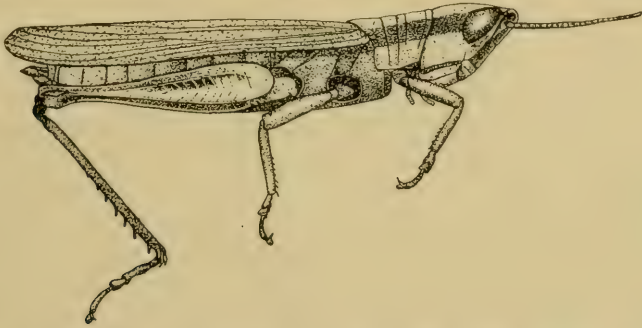


FIG. 21.—*OXYBLEPTELLA PULCHELLA*. LATERAL VIEW OF FEMALE TYPE. ( $\times 3$ )

suture, margins well elevated, surface of costa and face between facial supplementary carinæ impresso-punctate; supplementary facial carinæ moderately divergent dorsad, decidedly divergent ventrad, more particularly in the female; eyes rather large, elongate acute-subpyriform, moderately prominent when seen from the dorsum, length nearly three times that of the infra-ocular portion of the genæ; antennæ distinctly shorter than the head and pronotum together, very appreciably depressed, very slightly ensiform, apex blunt. Pronotum with its greatest dorsal width contained one and two-thirds (female) to one and three-fourths (male) times in the greatest length, dorsum moderately arcuate in transverse section; cephalic margin arcuate (male) or arcuato-truncate (female), caudal margin with a hardly appreciable angle in the male, very slightly but distinctly obtuse-angulate in the female, lateral angles very much rounded on the prozona, apparent but rounded on the metazona; disk of the



pronotum subequal in width, median carina low, rather coarse, marked on all of the pronotum, transverse sulci three in number; metazona equal to (male) or exceeding (female) two-thirds the length of the prozona; lateral lobes distinctly longer than deep, the ventral margin with a very slight obtuse-angulation. Tegmina about one



FIG. 22.—  
OXYBLEP-  
TEL LA  
PULCH-  
ELLA. DOR-  
SAL OUT-  
LINE OF  
HEAD AND  
PRONO-  
TUM OF  
MALE.  
(X 3)

and two-thirds (male) to twice (female) the length of the head and pronotum together, narrow, subequal; costal margin with a hardly appreciable lobe and a moderate distal arcuation, sutural margin nearly straight, apex with a slight oblique truncation, the extreme apex narrowly rounded; distinct intercalary vein present. Wings extending to the tips of the tegmina.

Prosternal process transverse, the apical margin arcuate emarginate, the lateral angles bluntly protuberant, not retrorse; interspace between the mesosternal lobes strongly longitudinal, the length about four times the width, the interspace hardly more than a third the width of one of the lobes; metasternal lobes contiguous in both sexes. Abdomen hardly compressed; supra-anal plate of the male short, stout pyriform, the greatest width slightly more than the length, apex bluntly rounded; a pair of blunt tubercles placed a short distance proximad of the apex; cerci of the

male simple, robust in the proximal third, then strongly bent dorsad and tapering to the apex which is curved inward toward the median line; subgenital plate of the male acute-angulate when seen from the dorsum, apex well rounded when seen from the side. Cephalic and median limbs very short, the femora slightly more robust in the male. Caudal femora reaching about to the apex of the abdomen in both sexes, somewhat compressed, moderately robust in the proximal half, tapering distad, the genicular extremity quite small; caudal tibiae appreciably shorter than the femora, armed on the external margin with seven spines, on the internal margin with ten, both margins with slight lamellate expansions distad, the tibiae appreciably broadened in the same portion.

General color gamboge yellow, broad postocular bars of vandyke brown, slightly darker in the male, extending caudad over the dorsum of the lateral lobes and the same portion of the pleura, represented on the costal half of the tegmina by the prout's brown infuscation of the region, a narrow cloud along the dorsum of the pagina of the caudal femora vandyke brown, slightly chocolate on its ventral edge; face walnut brown, the area thus colored limited by a pair of strongly divergent dark lines which extend ventrad from the insertion of the antennae; eyes



FIG. 23.—OXYBLEPTEL-  
LA PUL-  
CHELLA.  
DORSAL  
OUTLINE OF  
HEAD AND  
PRONOTUM  
OFFEMALE.  
(X 3)

raw umber; antennæ pale russet; a very narrow median line on the fastigium, occiput and pronotum seal brown in the male, in the female olive green on the head, liver brown on the pronotum; spines on caudal tibiæ with the apical halves blackish.

*Measurements.*

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body .....	20	23.8
Length of pronotum .....	3	4
Length of tegmen.....	12.8	16.2
Length of caudal femur.....	9.5	12

One paratype male (June) and two paratype females (April and May) have been examined in addition to the types. They do not exhibit any noteworthy difference from the typical pair.

Genus *INUSIA* Giglio-Tos.

*INUSIA BONITENSIS*, new species.

*Type*.—Male; Bonito, Pernambuco, Brazil. January, 1883. (A. Koebele.) Cat. No. 12090. U.S.N.M.

Allied to *I. pallida* Bruner from Paraguay<sup>a</sup> but differing in the more prominent eyes and the broader, darker lateral bars.

Size small; form elongate, slightly compressed; surface of head, pronotum, pleura and to an extent the dorsum of the abdomen punctulate, the pronotum, pleura and face with the impressions closely placed and sharply defined. Head with the exposed dorsal length contained one and one-half times in the length of the pronotum; occiput decidedly ascending to the sub-horizontal interocular region, which latter is hardly more than a third the greatest width of the fastigium, a slight median carina present on the interocular region and occiput; fastigium acute-lanceolate; fastigio-facial angle sub-rectangulate, the interocular rostrum with its outline curving gently from the dorsal angle to a short distance ventrad of the insertion of the antennæ, whence the facial line is regularly and very considerably retreating; frontal costa very narrow, subequal in width, very slightly expanding dorsad of the insertion of the antennæ, distinct and sulcate from the fastigio-facial angle to the clypial suture; supplementary facial carinæ distinct, sub-parallel, slightly convex sinuato-arcuate; eyes quite prominent, ovate in outline, the length slightly greater than that of the infra-ocular portion of the genæ; antennæ lacking. Pronotum with the greatest dorsal width contained about twice in the length of the same; cephalic and caudal margins arcuate obtuse-angulate; median

<sup>a</sup> Proc. U. S. Nat. Mus., XXX, 1906, p. 660.

carina slight and low but quite apparent on the whole dorsum; lateral angles moderately rounded on the prozona, very slightly rounded on the metazona, the disk very gradually widening caudad; transverse sulci three in number, distinct, narrow, metazona about three-fifths of the entire length of the pronotum; lateral lobes very considerably longer than deep, the ventral margin strongly arcuate-



FIG. 24.—*INUSIA BONITENSIS*. LATERAL VIEW OF TYPE. ( $\times 3$ )

emarginate cephalad, caudal section of the ventral margin straight, the ventro-caudal angle very broadly rounded. Tegmina very long and slender, exceeding the tips of the caudal femora by nearly the length of the pronotum, subequal; apex lanceolate. Wings equal to the tegmina. Prosternal spine conic, blunt, slightly retrorse; interspace between the mesosternal lobes slightly longitudinal, the interspace but little more than half the width of one of the lobes, the internal margin of the lobes convex arcuate; metasternal lobes contiguous. Abdomen slightly compressed; supra-anal plate lanceolate, the margin notched distad of the middle for the reception of the cerci, disk considerably depressed; cerci robust and tapering in the proximal half, thence sharply bent dorsad and narrowed to about a third the proximal width, tapering to the rather blunt apex, the axis of the cercus from the median bend being slightly toward the median line of the body, then curved slightly laterad at the tip; subgenital plate moderately compressed, the dorsal margins acute-angulate but not reaching to the inflated, sub-bulbous apex, the latter being moderately rounded when seen from the side. Cephalic and median limbs rather slender. Caudal femora surpassing the apex of the abdomen, the length being two and one-half times that of the pronotum, somewhat compressed, proximal portion regularly and evenly, but not greatly, inflated, tapering to the genicular region, genicular lobes moderately acute-angulate, pagina regularly and in the proximal section very closely patterned; caudal tibiae distinctly shorter than the femora, the distal portion considerably inflated, the margins



FIG. 25.—*INUSIA BONITENSIS*. DORSAL OUTLINE OF HEAD AND PRONOTUM OF TYPE. ( $\times 3$ )



lamellate, external one armed with six spines, internal with ten; caudal tarsi with the proximal joint very considerably depressed and expanded.

General color wax yellow, quite greenish on the dorsum and tending toward gamboge yellow on the caudal limbs and abdomen; postocular bars vandyke brown, broad and reaching to the apex of the tegmina, covering all but the anal area of the same; eyes russet, clouded with vandyke brown dorso-caudad; caudal tibiae clouded with brownish, the spines yellowish very narrowly tipped with black.

*Measurements.*

	Mm.
Length of body .....	17.5
Length of pronotum .....	3.8
Length of tegmen .....	16.6
Length of caudal femur .....	10.6

The type alone has been examined.

Genus *STENOPOLA* Stål.

*STENOPOLA PUNCTICEPS* (Stål).

1860. *Opsomala puncticeps* STÅL, Kong. Svenska Freg. Eugenies Resa, Ins., p. 325.  
[Rio Janeiro, Brazil.]

Corumbá, Matto Grosso, Brazil. March; highland. (H. H. Smith.)  
One female.

This specimen is appreciably smaller than a specimen from Sapucay, Paraguay.

The range of this species now extends from San Lorenzo, Jujuy, Argentine, east to Rio Janeiro and from Sapucay, Paraguay, to Corumbá, Matto Grosso.

*STENOPOLA BOHLSII* Giglio-Tos.

Corumbá, Matto Grosso, Brazil. March and May; highland. (H. H. Smith.) One male, four females.

The range of this species now extends from Resistencia Chaco, Argentina, to Corumbá.

Genus *PARACORNOPS* Giglio-Tos.

1894. *Paracornops* GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, IX, No. 184, p. 31.

*Type*.—*Acrydium longipenne* De Geer.

*PARACORNOPS AQUATICUM* Bruner.

1906. *Paracornops aquaticum* BRUNER, Proc. U. S. Nat. Mus., XXX, p. 663.  
[San Bernardino and Sapucay, Paraguay.]

Corumbá, Matto Grosso, Brazil. March; lowland. (H. H. Smith.)  
Two males, two females.

Cuyabá, Matto Grosso, Brazil. February. (H. H. Smith.)  
One male.



One of the female individuals is quite large, considerably exceeding the other female and the original measurements in size. There appears to be considerable variation in the depths of the coloring of the dark lateral bars, one specimen from Corumbá having them quite faintly indicated.

Genus *MASTUSIA* Stål.

1878. *Mastusia* STÅL, Bih. till Kong. Svenska Vet. Akad. Handl., V, No. 4, pp. 39 and 84.

*Type*.—*Mastusia quadricarinata* Stål.

*MASTUSIA KOEBELEI*, new species.

*Types*.—Male and female. Bonito, Pernambuco, Brazil. January 18, 1883 (male); February, 1883 (female). (A. Koebele.) Cat. No. 12091, U.S.N.M.

Differing from *Mastusia quadricarinata* from Peru in the much smaller size, shorter and narrower tegmina and different coloration.

Bolívar's *M. spectabilis*<sup>a</sup> from the Upper Amazon region is not closely related to the new form.

Size small; face and surface of the thoracic segments punctate, the pronotum strongly so. Head with its exposed dorsal surface two-thirds (female) to four-fifths (male) the length of the pronotum; occiput slightly ascending very slightly arcuate; interocular space about one-half (male) to three-fifths (female) the greatest width of the fastigium; fastigium broad, very short, horizontal, the angle obtuse-angulate in both sexes, more decidedly so in the female than in the male; surface very slightly depressed within the margins; fastigio-facial angle acute-angulate, the immediate angle well rounded, facial line very decidedly retreating; frontal costa broad, subequal, but very slightly expanded between the antennæ, narrowed dorsad of the antennæ to joint the fastigium, a slight constriction present at the ocellus, margins distinctly elevated, surface moderately excavate and distinctly punctate; supplementary facial carinæ prominent, regularly and decidedly divergent caudad; eyes moderately prominent in both sexes, acute-ovate in outline, the length about half that of the infra-ocular portion of the genæ; antennæ slightly shorter than the head and pronotum together (male) or no longer than the pronotum (female), slightly depressed, very slightly narrowed toward the base. Pronotum with the greatest caudal width of the disk contained approximately one and one-half times in the length of the same; cephalic margin slightly arcuate (male) or arcuato-truncate (female), caudal margin distinctly emarginate mesad, the sides of the emargination convex, lateral angles very well rounded; median carina distinct, but very low, principal transverse sulcus the only one severing the carina, metazona about a

<sup>a</sup> Anal. Soc. Esp. Hist. Nat., XIX, p. 325.

third the length of the prozona; lateral lobes slightly longer than deep, ventral margin slightly but distinctly arcuate-emarginate cephalad, the caudal section of the margin very bluntly obtuse-angulate, the ventro-caudal angle rounded. Tegmina extending slightly caudad of the margin of the metanotum, sub-lanceolate, the greatest width contained approximately three to four times in the length, apex moderately angulate. Wings very minute, lobiform, covered by the tegmina. Abdomen distinctly compressed, tectate dorsad; supra-anal plate short, transverse, the apical margin rectangular, disk considerably excavate; cerci moderately long, with a considerable arcuation dorsad before the middle, the apex blunt, with a sharply bent spine directed ventro-cephalad toward the median line; subgenital plate elevated and produced distad, strongly compressed and sub-lamellate in that portion, the apex when seen from the side well rounded. Prosternal process transverse, the apical margin rectangular, the angles slightly spiniform; interspace between the mesosternal lobes distinctly longitudinal, about twice as long as wide, with the interspace about two-thirds the width of one of the lobes (male) or wedge shaped with the narrowest (caudal) portion of the interspace slightly less than half the length of the same (female); metasternal lobes contiguous in both sexes. Cephalic and median limbs very short, rather slender in the female. Caudal femora reaching to (female) or exceeding (male) the apex of the abdomen, moderately robust, tapering, genicular lobes bluntly angulate, pagina regularly and rather closely patterned; caudal tibiae distinctly shorter than the femora, slightly dilated distad, the margins distinctly lamellate in that portion, lateral margin with seven to eight spines, internal margin with ten to eleven spines; caudal tarsi with the proximal joint moderately depressed and dilated.

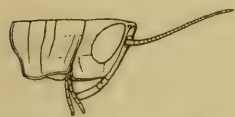


FIG. 27.—*MASTUSIA KOEBELI*. LATERAL OUTLINE OF HEAD AND PRONOTUM OF FEMALE TYPE. ( $\times 3$ )

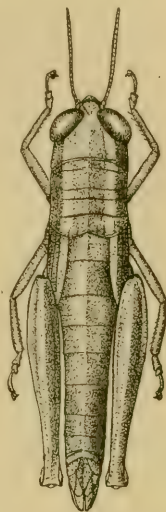


FIG. 26.—*MASTUSIA KOEBELI*. DORSAL VIEW OF FEMALE TYPE. ( $\times 3$ )

General color russet, a broad postocular bar extending over the dorsal half of the lateral lobes, the ventral half of the tegmina and dorsal portion of the pleura vandyke brown, continued on the sides of the abdomen as a series of blotches of the same color in the female, as a bar in the male, becoming weaker distad in both sexes; ventral half of the lateral lobes, genæ and pleura wood brown; face with a pair of more (male) or less (female) divergent dark lines ventrad of the insertion of the antennæ; occiput with a dark brown median bar in the male; caudal tibiae vandyke brown distad, spines pale yellow, tipped with blackish.

## Measurements.

	Male.	Female.
	mm.	mm.
Length of body.....	15.2	18
Length of pronotum.....	3	3.3
Length of tegmen.....	3.3	2.8
Length of caudal femur.....	9.2	10.2

One paratype male (February) and four paratype females (January and February) have also been examined. There is an appreciable amount of variation in color, some being more greenish than the types, while one has the color pattern very weak. Aside from this, however, they agree very well with the types.

## Genus ALEUAS Stål.

## ALEUAS VITTICOLLIS Stål.

1878. *A[leuas] vitticollis* STÅL, Bih. till Kong. Svenska Vet. Akad. Handl., V, No. 4, p. 69. [São Leopoldo, Rio Grande do Sul, Brazil; Montevideo, Uruguay.]

Corumbá, Matto Grosso, Brazil. March. (H. H. Smith.) One male.

This specimen is slightly larger than the original measurements given by Stål, being 40 mm. instead of 35 mm. in the length of the body.

## Genus PARALEUAS Giglio-Tos.

## PARALEUAS FRATER, new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. June (male); November (female). (H. H. Smith.) Cat. No. 12093, U.S.N.M.

Closely allied to *Paraleuas minor* Bruner<sup>a</sup> from Victoria, Brazil, but differing in the longer tegmina which average 15.2 mm. in the male and 14.5 in the female in the series in hand, instead of 11 and 12 mm. as in *P. minor*. The other proportions of the species are about the same.

Size very small; form moderately elongate and slender; surface of the pronotum and pleura strongly punctate, of the face moderately punctate. Head with its exposed dorsal length equal to three-fifths (female) or four-fifths (male) the dorsal length of the pronotum; occiput slightly ascendent, arcuate, interocular space narrow, hardly (male) or about (female) a third the greatest width of the fastigium, interocular region slightly descending; fastigium sub-horizontal, blunt rectangulate in both sexes, apex sub-truncate, margins distinct, disk very shallowly but distinctly excavate; fastigio-facial angle rounded rectangulate, more distinctly rounded in the female than the male, facial line very considerably retreating from between

<sup>a</sup> Proc. U. S. Nat. Mus., XXX, 1906, 669.



the antennæ: frontal costa inflated dorsad, distinctly (male) or slightly (female) constricted ventrad of the ocellus, the ventral portion subequal, sulcate ventrad of the interantennal region, punctate dorsad, biseriate in the female, irregularly in the male; supplementary facial carinæ prominent, moderately divergent arcuato-convex; eyes quite (male) or moderately (female) prominent, sub-ovate in outline, the length about twice that of the infra-ocular portion of the genæ; antennæ about one and one-third times the length of the head and pronotum, slightly heavier in the male than in the female. Pronotum



FIG. 28.—*PARALEUAS FRATER*. LATERAL VIEW OF THE FEMALE TYPE. ( $\times 3$ )

very slightly sellate, with the greatest dorsal width of the disk contained about one and one-half times in the length of the same; cephalic margin arcuate, caudal margin rounded obtuse-angulate; median carina very low, hardly appreciable on the prozona in the male, apparent cephalad on that portion in the female, present though very weak on the metazona in both sexes, lateral angles very broadly rounded, a slight shoulder on the metazona; transverse sulci three in number; metazona about two-thirds the length of the prozona; lateral lobes with the dorsal length greater than the depth, ventral margin obliquely arcuato-truncate caudad, considerably sinuato-emarginate cephalad, ventro-cephalic angle marked, slightly obtuse, ventro-caudal angle rounded broad obtuse. Tegmina slightly (female) or considerably (male) surpassing the apex of the abdomen, very (male) or moderately (female) narrow, subequal, apex lanceolate. Wings ample. Prosternal spine slightly compressed, very low and blunt; interspace between the mesosternal lobes longitudinal, moderately (female) or decidedly (male) constricted mesad, making the interspace hour-glass shaped; metasternal lobes contiguous. Abdomen somewhat (female) or



FIG. 29. *PARALEUAS FRATER*. DORSAL OUTLINE OF HEAD AND PRONOTUM OF FEMALE TYPE. ( $\times 3$ )

decidedly (male) compressed; supra-anal plate of the male moderately lanceolate; cerci of the male simple, styliform, reaching about to the apex of the subgenital plate; subgenital plate short, slightly compressed, blunt, the apical margin arcuate when seen from the side; ovipositor jaws of the female rather elongate, compressed. Cephalic and median limbs very short. Caudal femora falling



slightly (male) or considerably (female) short of the apex of the abdomen, robust, somewhat compressed, pagina regularly and closely patterned, genicular lobes slightly acute-angulate; caudal tibiae slightly shorter than the femora, lateral margin with seven to eight spines, internal margin with nine to ten spines; caudal tarsi slender, elongate, second joint very slightly more than half the length of the proximal one.

General color of the dorsum russet in the male, mars brown in the female. The broad postocular bar extending caudad over the dorsal half of the lateral lobes and dorsum of the pleura bistre; face drab; genae and ventral portions of the lateral lobes and of the pleura naples yellow. Tegmina of the dorsal color in the male, vandyke brown in the female, the surface entirely covered with a mottled lighter and darker pattern of small subquadrate blotches; wings very pale brownish hyaline, very faintly clouded at the apex. Abdomen with its dorsal and lateral aspects brownish black; entire venter tawny-olive, darker on the meso- and metasternum. Caudal femora yellow with the entire external face more or less distinctly clouded with very dull brownish purple; internal face with three spots of dark brown, one median, one pre-apical, one genicular; caudal tibiae very dull glaucous becoming dark brownish distad, spines tipped with blackish brown. Eyes raw umber; antennae dull rufous.

*Measurements.*

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	15	19.5
Length of pronotum.....	2.6	3.3
Length of tegmen.....	14	15.5
Length of caudal femur.....	8.2	9.2

Three paratypic specimens have been examined in addition to the types, one being a male, the others females, the months represented being August and November. There is no variation of importance except some slight difference in color, the paratypic male being quite yellowish.

Genus *JODACRIS* Giglio-Tos.

*JODACRIS FERRUGINEA* (Giglio-Tos).

Chapada, Matto Grosso, Brazil. September, October, and November; one specimen labeled as taken in campo. (H. H. Smith.) One male, five females.

These specimens have been compared with Paraguayan representatives and prove to be inseparable. The male individual is more strikingly colored than any of the females, the yellowish ochre

on the caudal femora, dorsum of the pronotum, genæ, and ventral portions of the lateral lobes being quite striking, relieved as it is by the otherwise dull color of the insect. Two of the females are quite uniformly colored, the dark femoral bars being represented only by the faintest suggestion and the usual pale bars on the head and lateral lobes of the pronotum are not at all indicated. The general shade of one of the uniform specimens is very dull purplish red.

This species is now known to range from Chapada to Villa Rica, Paraguay.

*JODACRIS FURCILLATA*, new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. July (male) and August (female). (H. H. Smith.) Cat. No. 12093, U.S.N.M.

Allied to *J. ferruginea* but differing in the slightly smaller size, the proportionately slenderer form, and in the shorter and more distinctly incurved cerci of the male.



FIG. 30.—*JODACRIS FURCILLATA*. LATERAL VIEW OF MALE TYPE. ( $\times 4\frac{1}{2}$ )

Size rather small; form moderately slender; surface punctate, the abdomen of the female much smoother than that of the male. Head with its dorsal length about equal to (female) or slightly exceeding (male) the length of the prozona; occiput very slightly rounded; interocular region narrow, slightly (female) or distinctly (male) more than half the greatest fastigial width; fastigium rounded obtuse angulate, the greatest width more than the length, the apex subtruncate, the surface when seen from the side somewhat declivent, slightly excavate mesad and in the intermarginal region; fastigio-facial angle obtuse, the line of the face considerably retreating ventrad, the interantennal portion very slightly inflated; frontal costa of moderate breadth dorsad, slightly expanded between the antennæ, not sulcate, strongly punctate, immediately ventrad of the ocellus the costa is strongly and sharply constricted, ventrad of

which portion it is of moderate width, subequal, becoming weaker toward the clypeal suture, the portion ventrad of the ocellus sulcate; lateral facial carinae slightly arcuate and divergent dorsad, subparallel ventrad; eyes moderately prominent in both sexes, the length considerably (male) or slightly (female) greater than that of the infra-ocular portion of the genae, subovate in outline; antennae about equal to the head and pronotum in length, thick, slightly depressed proximad, apex blunt. Pronotum with the cephalic margin bearing a broad shallow median emargination, caudal margin obtuse-angulate, the immediate angle very blunt, the sides of the same slightly sinuate; median carina very low and weak, severed by three transverse sulci, the caudal of which is deeper than the others; metazona about two-thirds the length of the prozona, lateral angles broadly rounded except for a slight shoulder on the metazona; lateral lobes longer than deep, ventral margin obtuse-angulate, sinuate cephalad. Tegmina exceeding the apex of the abdomen in



FIG. 31. —  
JODACRIS  
FURCILLA-  
TA. DOR-  
SAL OUT-  
LINE OF  
APEX OF  
MALE AB-  
DOMEN.  
(X 5)

both sexes, in the male by the length of the pronotum, in the female by hardly more than that of the metazona, rather narrow, subequal, apex rounded, costal lobe small, no distinct intercalary vein. Prosternal spine slightly transverse, conic, acute; interspace between the mesosternal lobes slightly longitudinal (male) or subquadrate (female); metasternal lobes subcontiguous in both sexes. Supra-anal plate of the male elongate, somewhat produced, subequal in the proximal three-fifths, arcuate acute-angulate in the remainder, the lateral margins strongly thickened and inflated proximad, a distinct medio-longitudinal sulcus present on the proximal half, this portion

being divided from the distal by a low obtuse-angulate transverse carina, the distal section strongly arcuate in section, bearing mesad a pair of small teat-like nodes; cerci of the male heavy, elongate, reaching to the apex of the subgenital plate, the whole compressed, the proximal half subequal, the remainder tapering from the middle to the tip, which is abruptly bent inward at about three-fifths the length of the cercus, the dorsal margin bearing a short tooth-like process at about the point of flexure, from which to the base the margin is keeled; subgenital plate conic, the apex slightly blunt when seen from the side. Ovipositor jaws of the female very slightly and weakly serrate. Cephalic and median limbs of medium size, the femora of the male slightly inflated. Caudal femora quite robust, the length about one and one-half times that of the head and pronotum together, the greatest width contained about three times in the length of the femur, pagina regularly and closely patterned; caudal tibiae with seven spines on the external

margin and nine on the internal. General color uniform walnut brown in the male, chocolate in the female, the abdomen cinnamon in both sexes. Caudal femora walnut brown in both sexes, the tibiae pale verdegris green, washed with pale brown proximad and distad, the spines tipped with blackish, tarsi walnut brown. Eyes tawny-olive; antennæ vinaceous-rufous, darker near the tip.

*Measurements.*

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	16.2	20.8
Length of pronotum.....	3.5	3.8
Length of tegmen.....	15	17.2
Length of caudal femur.....	9	10

The types are unique.

Genus *OMALOTETTIX* Bruner.

*OMALOTETTIX NEBULOSA* (Bruner).

Chapada, Matto Grosso, Brazil. September. (H. H. Smith.) One female.

This specimen has been compared with material from Sapucay, Paraguay.

*OMALOTETTIX SIGNATIPES* Bruner.

Chapada, Matto Grosso, Brazil. April. (H. H. Smith.) Two males, two females.

Bonito, Pernambuco, Brazil. January, 1883. (A. Koebele.) One male, one female.

Espirito-Santo, Brazil. [Hebard collection.] One female.

The individuals from Bonito appear to have the wings proportionately longer and slenderer than is the case with Chapada and Sapucay, Paraguay, material, while they are also distinctly inferior in size. A specimen of this species from the island of St. Thomas, West Indies (December, 1882; A. Koebele), is intermediate in size between the Chapada and Bonito males, but has the tegmina nearly as slender as in the latter.

The range of this species now extends from Temax, Yucatan, and St. Thomas, West Indies, to São Paulo, Brazil, and Sapucay, Paraguay.

Genus *LEPTOMERINTHOPRORA* Rehn.

1905. *Leptomerinthoprora* REHN, Proc. Acad. Nat. Sci. Phila., 1905, p. 436.

*Type.*—*Leptomerinthoprora brevipennis* Rehn.

The genus *Leptomerinthoprora* is a member of the *Vilernæ* and not of the *Xiphiolæ*, as previously stated by me, its nearest ally being *Nuceria* Stal, from which it differs in the short tegmina and wings,



the strongly rugulose pronotum, the distinctly elevated median carina of the pronotum, and in having seven outer tibial spines instead of eight.

LEPTOMERINTHOPRORA ÆQUALIS, new species.

*Type*.—Female. Bahia, Brazil. March 21, 1883. (A. Koebele.) Cat. No. 12094, U.S.N.M.

This new species differs from *Leptomerinthoprora brevipennis* from Pozo Azul, Costa Rica, in the less angulate fastigium, the less sulcate frontal costa, the more compressed pronotum with subparallel lateral angles and obtuse-angulate caudal margin, the longer and less trigonal tegmina, and slenderer ovipositor jaws.

Size medium; form moderately robust, slightly compressed; surface of the pronotum and pleura strongly punctate, the dorsum of the prozona with the punctations weak; head and abdomen sparsely and very shallowly punctate. Head with the exposed dorsal length about three-fifths the dorsal length of the pronotum; occiput moder-



FIG. 32.—LEPTOMERINTHOPRORA ÆQUALIS. LATERAL VIEW OF TYPE. (X 3)

ately arcuate, hardly elevated dorsad of the level of the pronotum, gently declivent in the interocular region to the fastigium, the width of the interocular region two-thirds the greatest fastigial width; fastigium very slightly acute-angulate in shape, the apex rather broadly subtruncate, the length of the fastigium about equal to the width of the interocular space, surface of the fastigium very slightly depressed within the margin; fastigio-facial angle obtuse, the inter-antennal region somewhat produced, the angle of the face distinctly retreating, the inter-antennal portion rounded; frontal costa moderately broad, subequal dorsad, regularly narrowed at its junction with the fastigium, distinctly but not sharply constricted ventrad of the ocellus, very slightly inflated immediately dorsad of the clypeal suture, sulcate from the ocellus ventrad, plane and punctate dorsad; lateral facial carinae prominent, regularly but not greatly divergent ventrad; eyes prominent, subovate in outline, the length about half again that of the infra-ocular portion of the genae; antennae about

equal to the length of the head and pronotum, thick, slightly depressed and subensiform proximad, apex blunt. Pronotum very slightly more than two-fifths the length of the caudal femur, dorsum nearly plane; cephalic margin arcuato-truncate, with a distinct but slight median emargination, caudal margin broadly obtuse-angulate, the immediate angle truncate and the entire margin crenulato-sinuate; median carina very low, weak on the prozona, lateral angles rounded, a shoulder present on the metazona; lateral lobes decidedly longer than deep, ventral margin sinuato-emarginate cephalad, median and ventro-caudal angles obtuse; transverse sulci three in number, the caudal deeper than the others, the prozona about three-fifths the length of the pronotum. Tegmina coriaceous, reaching about to the middle of the abdomen, lanceolate, the greatest width contained about three times in the length, costal lobe rather long but low. Wings slightly shorter than the tegmina. Prosternal spine erect, conic, slightly blunted at the apex; interspace between the mesosternal lobes subquadrate, slightly narrower than the width of one of the lobes; interspace between the metasternal lobes sub-trigonal, the distance separating the lobes being about half the length of the interspace. Abdomen moderately compressed, carinate dorsad; ovipositor jaws rather long, shallowly dentato-crenulate. Cephalic and median limbs of medium build. Caudal femora slightly less than one and one-half times the length of the head and pronotum together, moderately robust, the greatest width contained slightly more than three times in the length, pagina with a moderately regular but not very close pattern, dorsal carina entire, genicular lobes acute with the immediate apex well rounded; caudal tibiae slightly shorter than the femora, slightly sinuate, armed on the external margin with six to seven spines, on the internal margin with nine spines, no apical spine present on the external margin.

General color vandyke brown, a broad dorsal bar extending from the fastigium over the occiput, whole of the dorsum of the pronotum and all of anal areas of the tegmina ochraceous in color, clouded on the occiput and pronotum with vandyke brown. An irregular infra-antennal transverse bar and a broad bar covering the genæ, ventral portion of the lateral lobes and touching the pleura dull raw sienna. Abdomen raw umber. Eyes raw umber; antennæ dull gallstone yellow, becoming tawny proximad. Caudal femora with the external face clouded with blackish, the ventral portion of the internal face and the ventral face carmine for the greater part of their length; caudal tibiae similar to the ventral face of the femora, pale proximad, spines tipped with black.

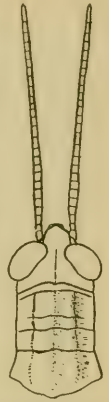


FIG. 33.—LEP-  
TOMERIN-  
THOPORA  
EQUALIS.  
DORSAL  
OUTLINE OF  
HEAD AND  
PRONOTUM  
OF TYPE.  
(X 3)

## Measurements.

	mm.
Length of body.....	25.5
Length of pronotum.....	5.5
Length of tegmen.....	9.5
Length of caudal femur.....	8

The type alone has been examined.

Genus MACHÆROPOLES,<sup>a</sup> new.

A member of the *Vilernæ*, but not closely allied to any of the other genera of the group. It is immediately separable by its elongate form, produced fastigium, and strongly retreating face. Some of the characters which appear to show relationship to other genera of the group previously mentioned are the form of the antennæ, the structure of the fastigium, the character of the frontal costa and facial carinæ, the tegminal venation and the structure of the limbs.

Body elongate fusiform. Fastigium produced, rostrate; face strongly retreating; frontal costa entire, sulcate, subequal dorsad, inflated ventrad; eyes elliptical to ovate, hardly prominent; antennæ serrate ensiform. Pronotum straight, median carina very slight, transverse sulci weak, no distinct lateral angles present. Tegmina elongate, subequal, exceeding the abdomen, apex rounded, an irregular intercalary vein present. Wings ample. Prosternal spine compressed, retrorse. Meso- and meta-sternal lobes contiguous or subcontiguous. Supra-anal plate of the male armed with numerous small nodes; subgenital plate compressed. Ovipositor jaws of the female slender. Median and cephalic limbs small. Caudal femora moderately robust; caudal tibiæ armed on the external margin with seven spines, on the internal margin with ten, no apical external spine present.

*Type*.—*Machæro poles rostratus*, new species.

## MACHÆROPOLES ROSTRATUS, new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. August (female), September (male). (H. H. Smith.) Cat. No. 12095, U.S.N.M.

Size medium; form very elongate fusiform, slightly compressed, venter flattened; surface more or less thickly punctate. Head with its dorsal length equal to (male) or slightly shorter than (female) the dorsal length of the pronotum; occiput horizontal; interocular space slightly less (male) or more (female) than half the fastigial width; fastigium slightly ascending, subequal in width proximad, acute-angulate distad, the disk with a slight medio-longitudinal carina distad and a pair of low lateral carina diverging cephalad,

<sup>a</sup> Μαχαίροπωλης, signifying a vender of swords.



the lateral and apical margins slightly elevated; fastigio-facial angle slightly rounded rectangulate, the apex of the rostrate inter-antennal region obliquely sub-truncate, the facial line arcuato-concave, very strongly retreating; frontal costa narrowed at its junction with the fastigium, slightly constricted some little distance dorsad and ventrad

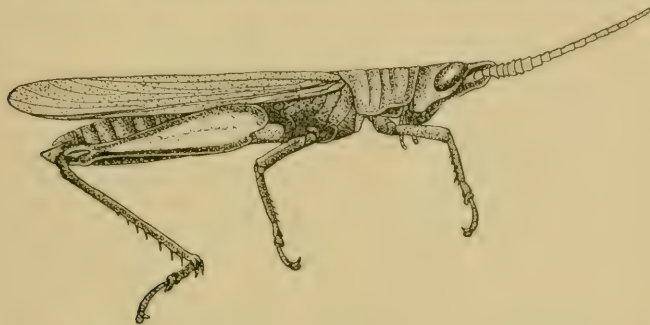


FIG. 34.—*MACHÆROPOLES ROSTRATUS*. LATERAL VIEW OF MALE TYPE. ( $\times 3$ )

of the ocellus, thence slightly arcuato-convex to the clypeal suture, sulcate throughout its length; lateral facial carinæ distinct, subparallel dorsad, slightly divergent ventrad; eyes hardly prominent, elliptical (male) or acute subovate (female) in outline, in length very slightly (female) or considerably (male) exceeding the infra-ocular portion of the genæ; antennæ about twice the dorsal length of the pronotum, very robust in the female, triquetrous, serrate ensiform. Pronotum with its dorsal length slightly less than half that of the caudal femora, dorsum straight cephalo-caudad, slightly arcuate transversely, the metazona slightly deplanate; cephalic margin arcuato-truncate, caudal margin arcuate obtuse-angulate, slightly sinuate; median carina very slight, broken by two sulci the caudal of which is the more apparent; lateral angles well rounded, a slight shoulder present on the metazona; lateral lobes very decidedly longer than deep, ventral margin sinuate emarginate cephalad, cephalic and caudal margin slightly sinuate, but more so in the female than in the male. Tegmina surpassing the apex of the abdomen by several millimeters in both sexes, narrow, subequal, the apex narrowly rounded, costal lobe hardly indicated; intercalary vein irregularly sinuate.

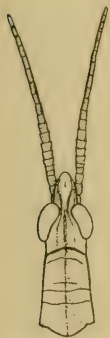


FIG. 35.—*MACHÆROPOLES ROSTRATUS*. DORSAL OUTLINE OF HEAD AND PRONOTUM OF MALE TYPE. ( $\times 3$ )

Prosternal spine considerably compressed, decidedly retorse, apex moderately acute in the male, rather blunt in the female; interspace between the mesosternal lobes nearly severed in the middle by the sub-attinent lobes in the male, very narrow and hour-glass shaped in the female; metasternal lobes attinent in the male, separated



by an interspace very slightly wider than that between the mesosternal lobes in the female. Abdomen carinate dorsad; terminal dorsal abdominal segment of the male with five small black points on the apical margin; supra-anal plate of the male slightly arcuate in section, the margins deflected dorsad, the shape of the plate acute-angulate, the surface with about nine small blackish nodes arranged in rows which reading caudad are four, two, one, and two; cerci short, rather thick, simple, styliform; subgenital plate moderately produced, compressed, sub-lamellate caudad, the apex when seen from the side blunted acute-angulate; ovipositor jaws slender, margins of dorsal pair blunt dentate-crenulate. Cephalic and median limbs very short, the femora slightly inflated in the male. Caudal femora about five-eighths the length of the tegmina, moderately slender, pagina with a rather close but not very regular pattern; caudal tibiae somewhat shorter than the femora; caudal tarsi with the proximal joint very appreciably expanded laterad.

General color of the male russet, of the female mummy brown, the latter with the tegmina mottled with wood brown in quadrate patches, the anal area chiefly of the latter color, while the median region is chiefly mummy brown. Eyes raw umber. Tegmina and caudal femora of the female inclined toward fawn, the cephalic and median limbs and caudal femora of the female blotched much as on the tegmina, but the darker color is nearer seal brown; internal face of the caudal femora orange vermilion crossed by four bands of black—one apical, one preapical, one premedian, one proximal. Caudal tibiae scarlet vermilion on half their length in the female, two-thirds of their length in the male, the proximal remainder similar to the femora in both sexes; spines with their apical halves black.

*Measurements.*

	Male.	Female.
	mm.	mm.
Length of body.....	23.5	31.5
Length of pronotum.....	4.2	5.8
Length of tegmen.....	17	23
Length of caudal femur.....	10.2	13

A series of one male and three female topotypic specimens have been examined, all taken in June. In size the females are all smaller than the type of that sex, but no striking structural variations are apparent. All of the topotypic specimens agree with the male type in color, a few, however, showing traces of the mottled tegminal pattern.

Genus HOMALOSAPARUS Rehn.

1908. *Homalosaparus* REHN, Proc. Acad. Nat. Sci. Phila., 1908, p. 17.

*Type.*—*Homalosaparus canonicus* Rehn.

## HOMALOSAPARUS SORDIDATUS, new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. June. (H. H. Smith.) Cat. No. 12096, U. S. N. M.

Closely allied to *Homalosaparus canonicus* from São Paulo, Brazil, but differing in the broader, blunter fastigium, slightly narrower eye, and the longer, more compressed pronotum which has the caudal margin more distinctly rectangulate.

Size rather large; form distinctly but not very greatly compressed; surface of the face, pronotum, and pleura punctate, dorsum of the head somewhat rugulose. Head with its dorsal length about two-thirds that of the pronotum; occiput slightly ascending to the vertex, which is interocular and equal to about three-fourths of the extreme fastigial width; fastigium subhorizontal (female) or slightly declivent (male) when seen from the side, rectangulate (male) or slightly obtuse-angulate (female) in shape, the apex slightly (male) or considerably (female) blunted, the sides of the angle slightly arcuato-concave in the male, the margins slightly elevated in the same sex,

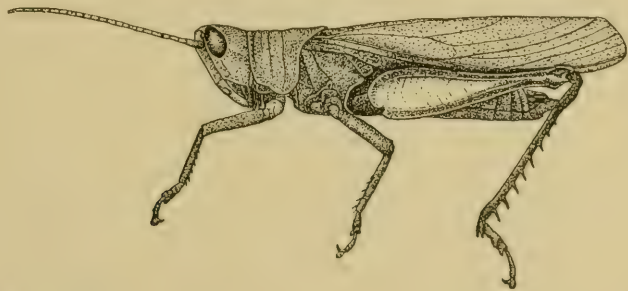


FIG. 36.—*HOMALOSAPARUS SORDIDATUS*. LATERAL VIEW OF MALE TYPE. ( $\times 1\frac{1}{2}$ )

surface with a slight medio-longitudinal sulcus, not impressed in the female; lateral foveolæ impresso-punctate, arcuate elongate trigonal in the male, broader and less impressed in the female; fastigio-facial angle rounded rectangulate, the angle of the face considerably retreating from between the antennæ ventrad; frontal costa rather narrow, considerably (male) or hardly (female) compressed dorsad, subequal ventrad, becoming obsolete some distance dorsad of the clypeal suture, punctate dorsad of the ocelli, sulcate ventrad; lateral facial carinæ strongly and regularly divergent; eyes not prominent, elongate acute-ovate in shape, the length about equal to (female) or slightly more (male) than that of the infra-ocular portion of the genæ; antennæ slightly longer (male) or very slightly shorter (female) than that of the head and pronotum together, somewhat depressed proximad, subensiform, apex subacute. Pronotum with the dorsum horizontal, very slightly arcuate in section; cephalic margin subtruncate, caudal margin rectangulate in the male, obtuse-angulate in

the female; median carina very low, slightly irregular, subobsolete between the sulci, lateral angles not marked, a moderate shoulder present on the metazona; transverse sulci three in number, the caudal one the deeper, the metazona very slightly longer than the prozona; lateral lobes about as deep as long, ventral margin well emarginate cephalad, arcuate caudad, the ventro-caudal angle rounded obtuse-angulate. Tegmina elongate, exceeding the apex of the abdomen by about the length of the pronotum, broad, the greatest width contained about four and one-half times in the tegminal length, this greatest width being in the proximal third; costal lobe moderately prominent, the costal margin well arcuate in the proximal fourth, apex considerably oblique truncate, the extreme angle blunt rectangulate. Wings reaching very nearly to the apex of the tegmina. Prosternal spine rather slender, acute, slightly retrorse; interspace



FIG. 37. — *HOMALOSA PARUS SORDIDATUS*.  
DORSAL OUT-  
LINE OF HEAD  
AND PRONOTUM OF MALE.  
( $\times 1\frac{1}{2}$ )

between the mesosternal lobes distinctly longitudinal, rather sharply (male) or slightly (female) narrowed cephalad of the middle; mesosternal lobes subcontiguous (male) or separated by a subquadrate interspace (female). Abdomen slightly carinate, moderately compressed; supra-anal plate of the male produced trigonal, the middle of the sides with a small triangular projection which is excavate dorsad, an angulate impression with its apex cephalad extends across the plate from one of these projections to the other, the distal portion of the plate slightly compressed, the apex rounded; cerci of the male not quite reaching to the apex of the supra-anal plate, simple, substyliform, the proximal three-fifths subequal in width; subgenital plate of the male strongly compressed from about the tips of the cerci, produced, the margins arcuate when seen from the side, apex acute; dorsal ovipositor jaws of the female with the margins unarmed. Cephalic and median limbs rather slender, of median

length. Caudal femora slightly exceeding (male) or equalling (female) the apex of the abdomen, well inflated proximad, the greatest width contained three and three-quarter times in the length, medio-dorsal carina serrate, pattern of the pagina regular and moderately close; caudal tibiae distinctly shorter than the femora, somewhat sinuate, the external margin armed with nine spines, the external apical spine present, the internal margin with ten spines.

General colors isabelline, wood brown, and russet, mottled and clouded one on the other, the only marked color pattern being on the male, this consisting of small spots of prout's brown on the dorsum of the pronotum and two quadrate spots of the same color on the proximal two-fifths of the dorsal face of the caudal femora. Caudal tibiae ochraceous, the spines tipped with black. The tegmina have a number of subobsolete oblique linear clouds of prout's brown crossing their median and discoidal areas.



## Measurements.

	Male.	Female.
	mm.	mm.
Length of body.....	31	39
Length of pronotum.....	6.5	7.8
Length of tegmen.....	26.8	34
Length of caudal femur....	17	20

A paratype series of one male and two females taken in June and November have also been examined. In color there is a fair amount of variation, one male and one female being quite reddish, while the other female is vandyke brown in general tone, livened on the sides with olive.

## Genus XIPHIOLA Bolivar.

## XIPHIOLA BORELLII Giglio-Tos.

Chapada, Matto Grosso, Brazil. April, June, and August. (H. H. Smith.) Three males, two females.

This species is now known to range over the country adjacent to the Paraguay River from Sapucay, Paraguay, north to Chapada.

## Genus SCHISTOCERCA Stål.

## SCHISTOCERCA DESILIENS Scudder.

1899. *Schistocerca desiliens* SCUDDER, Proc. Amer. Acad. Arts and Sci., XXXIV, p. 455. [Rio de Janeiro and Victoria, Brazil.]

Bahia, Brazil. March 21, 1883. (A. Koebele.) One male.

Bonito, Pernambuco, Brazil. January, February, and July, 1883. (A. Koebele.) Two males, five females.

Pernambuco, Pernambuco, Brazil. January 4, 1883. (A. Koebele.) One female.

Several of the specimens here recorded from Bonito are labeled as having been "collected on cotton."

This species appears to connect the *pyramidata-zapoteca* type with the *flavofasciata-infumata* series, though it seems quite probable that *desiliens* is nothing but a geographic race or form of *flavo-fasciata*. Bruner has observed this species at Asuncion, Paraguay.

## SCHISTOCERCA FLAVOFASCIATA (De Geer).

1773. *Acridium flavo-fasciatum* DE GEER, Mém. Hist. Ins., III, p. 489, pl. XL, fig. 8. [Surinam.<sup>a</sup>]

"From the locality it would seem there exists a strong possibility that this name was originally based on the form to which Scudder gave the name *æqualis*. Nothing diagnostic enough to settle the matter is contained in the original De Geerian description, and without Surinam material we would hardly be justified in stating that specimens from that locality are identical with Demerara individuals, which were the basis of *æqualis*, although the probability is of course very great. The statement made by Scudder (Proc. Acad. Arts and Sci., XXXIV, p. 456) that the species was originally described from Brazil was probably due to Stål's use of Brazil as the habitat of the species (Recensio Orthopterorum, I, p. 67). De Geer, however, distinctly gives Surinam as the source.



Rio de Janeiro, Brazil. November and December. (H. H. Smith.) One male, four females.

One of the female specimens shows a tendency toward *Schistocerca desiliens* in the maculation of the tegmina and the blackish maculation of the lateral lobes of the pronotum. As a whole, however, it appears to be nearer *S. flavofasciata*.

**SCHISTOCERCA PALLENS** (Thunberg).

1815. *G[ryllus] pallens* THUNBERG, Mém. Acad. Imp. Sci. St. Pétersbourg, V, p. 237. [No locality cited.]

Chapada, Matto Grosso, Brazil. July, September. (H. H. Smith.) One male, one female.

Previous records of *S. americana* from Guadalajara and Cuernavaca, Mexico, by the author<sup>a</sup>, are in part this species, as a re-examination of the material shows.

**Genus PARADICHROPLUS** Brunner.

1893. *Paradichroplus* BRUNNER, Ann. Mus. Civ. Stor. Nat. Genova, XXXIII, p. 145.

Based on Division II of the genus *Pezotettix* of Stål.<sup>b</sup> The two included species are both members of *Paradichroplus* as now understood, and the first, *mexicanus* Brunner, can be considered the type.

**PARADICHROPLUS FUSIFORMIS** Giglio-Tos.

1897. *P[aradichroplus] fusiformis* GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, XII, n. 302, p. 35. [San Lorenzo, Jujuy, Argentina; San Francisco, Bolivian Chaco.]

Chapada, Matto Grosso, Brazil. April. (H. H. Smith.) Five females.

One of the specimens studied is appreciably smaller than the others, but exhibits no other differences worthy of note.

This species has been found at Urucum and Carandasinho, near Corumbá, Brazil, and Asuncion, Paraguay, in addition to the localities cited above.

**PARADICHROPLUS BIPUNCTATUS** Giglio-Tos.

1894. *P[aradichroplus] bipunctatus* GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, IX, n. 184, p. 26. [Province of San Pedro and Asuncion, Paraguay.]

Corumbá, Matto Grosso, Brazil. March; highland. (H. H. Smith.) Four females.

One of these specimens measures as follows:

	mm.
Length of body .....	16.7
Length of pronotum .....	3.4
Greatest caudal width of pronotum .....	3.3
Length of tegmen .....	3
Length of caudal femur .....	10.2

<sup>a</sup> Trans. Amer. Ent. Soc., XXVII, p. 228; Proc. Acad. Nat. Sci. Phila., 1904, p. 534.

<sup>b</sup> Bih. till k. Svenska Vet.-Akad. Handl., V, no. 9, p. 8.

The species is now known to range from Corumbá to Formosa territory, Argentina, and from central Paraguay to San Lorenzo, Jujuy, Argentina.

Genus *DICHOPLUS* Stål.

*DICHOPLUS PUNCTULATUS* (Thunberg).

Bonito, Pernambuco, Brazil. January, 1883. (A. Koebele; one collected on cotton.) Two females.

Espirito Santo, Brazil. [Hebard collection.] One female.

Chapada, Matto Grosso, Brazil. April. (H. H. Smith.) Three males, two females.

*DICHOPLUS BRASILIENSIS* Bruner.

Rio de Janeiro, Brazil. November. (H. H. Smith.) One female.

Genus *LEIOTETTIX* Bruner.

*LEIOTETTIX VIRIDIS* Bruner.

Chapada, Matto Grosso, Brazil. (H. H. Smith.) One female.

This specimen is not separable from topotypic females from Sapucay, Paraguay.

Genus *PARASCOPAS* Bruner.

*PARASCOPAS OBESUS* (Giglio-Tos.).

Corumbá, Matto Grosso, Brazil. March; highland (2). (H. H. Smith.) One male, two females.

One of the female specimens is slightly smaller than the other, which latter represents the normal size when compared with females from Sapucay, Paraguay. The two specimens measure as follows:

	Male.	Female.
	mm.	mm.
Length of body.....	25.1	a 33
Length of pronotum.....	6.1	6.6
Greatest caudal width of disk of pronotum...	4.6	4.8
Length of tegmen.....	3.7	5
Length of caudal femur.....	16.7	17.1

a Abdomen unnaturally distended.

The range of this species is now known to extend from Corumbá to Asuncion and Sapucay, Paraguay.

*PARASCOPAS CHAPADENSIS*, new species.

*Types*.—Male and female. Chapada, Matto Grosso, Brazil. April. (H. H. Smith.) Cat. No. 12097, U.S.N.M.

Closely allied to *P. obesus*, but differing in the sigmoid cerci, the more prominent furcula and more elongate supra-anal plate of the male, the slightly broader tegmina, and the absence of sanguineous from the ventral aspect of the caudal femora.

Size medium. Head with its dorsal length about three-fourths (male) to four-fifths (female) that of the pronotum; occiput considerably inflated, arcuate, the vertex and fastigium strongly (female) or very considerably (male) declivent; interocular space half as wide as (male) or half again as wide as (female) the proximal antennal joint, narrowly sulcate in the male, moderately excavate in the female; fastigium short, much broader than long, the apical margin



FIG. 38.—*PARASCOPAS CHAPADENSIS*. LATERAL VIEW OF MALE TYPE. ( $\times 3$ )

truncate, the lateral margins slightly arcuato-concave, the surface considerably (male) or shallowly (female) excavate; fastigio-facial angle rounded broad obtuse-angulate, face considerably retreating, slightly arcuate, the interantennal region slightly produced in the male; frontal costa moderately broad, subequal, very slightly constricted immediately ventrad of the ocellus, about reaching the clypeal suture in the male, subobsolete a short distance dorsad of it



FIG. 39.—*PARASCOPAS CHAPADENSIS*. DORSAL VIEW OF APEX OF MALE ABDOMEN. ( $\times 6$ )

in the female, surface plane dorsad and slightly sulcate ventrad of the ocellus in the female, moderately sulcate ventrad and a distance dorsad of the ocellus in the male, the dorsal third biseriata punctate in the same sex; lateral facial carinae prominent, divergent; eyes prominent, particularly in the male, subovate (female) or short ovate (male) in outline, distinctly longer than the infraocular portion of the genae in both sexes; antennae filiform, elongate, in length less than half (female) or four-fifths (male) that of the body. Pronotum very lightly sellate, distinctly arcuate in transverse section; cephalic margin subarcuate with a very shallow median emargination.

caudal margin very slightly arcuate (male) or arcuato-truncate (female), lateral angles rounded, no appreciable shoulders present; median carina very weak and low, more apparent on the metazona than elsewhere; transverse sulci three in number, metazona about half the length of the prozona; lateral lobes distinctly longer than deep, ven-

tral margin arcuate-emarginate cephalad, the median angle rounded obtuse, ventro-caudal angle obtuse-angulate, the caudal margin arcuate-emarginate. Tegmina two-thirds (male) to four-fifths (female) the length of the pronotum, reaching to (male) or very slightly exceeding (female) the cephalic margin of the metanotum, subovate, the greatest width contained one and one-half times in the length, the apex very broadly and bluntly rounded in both sexes, broader, however, in the female. Wings minute. Prosternal process very low, blunt, slightly more prominent in the male than in the female; interspace between the mesosternal lobes narrow and decidedly longitudinal in the male, broader and subquadrate in the female; metasternal lobes subcontiguous in the male, in the female separated by a subtrigonal interspace which is decidedly narrowed caudad, the narrowest space separating them being slightly less than half the greatest. Abdomen slightly keeled dorsad; furcula of the male prominent, spiniform, subparallel, as long as the segment from which they arise; supra-anal plate of the male subtrigonal, the margins considerably arcuate-emarginate at the base of the cerci and slightly the same before the apex which is blunted acute-angulate, a broad shallow median depression present on the proximal three-fourths, margins considerably reflexed and distinctly elevated mesad, the elevated portion covered with small excrescences; cerci of the male rather slender, elongate, reaching to about the apex of the subgenital plate, sigmoid, elevated, the whole cercus compressed, more distinctly so mesad and distad, proximal third tapering, rather narrow mesad, the distal third, which is parallel to the axis of the body, slightly lamellate, apex moderately acute, the whole cercus regularly and gently curved toward the middle line to the proximal third which is slightly arcuate divergent; subgenital plate of the male inflated, recurved, the apex very close to the apex of the supra-anal plate and very blunt and low, the outline of the plate when seen from the side is moderately arcuate; ovipositor jaws of the female rather straight, the dorsal subequal proximad and mesad, the distal portion rather sharply hooked. Cephalic and median limbs moderately long, the femora very considerably inflated in the male. Caudal femora exceeding the apex of the abdomen in both sexes, of medium build, tapering, the greatest width contained about four times in the length, pattern of the pagina regular, genicular lobes with their apices rectangulate in the female, somewhat arcuate rectangulate in the male; caudal tibiæ slightly shorter than the femora, external margin armed with seven spines, internal with ten spines.

General color olive-green on the dorsum of the head, pronotum and abdomen, becoming saffron yellow ventrad and on the sides of the abdomen. Head with the face oil green in the male, dark olive-green in the female, the genæ much the same but slightly paler in



both sexes; a broad postocular bar of blackish brown extends from the caudal margin of the eye over the dorsal half of the lateral lobes, touching the dorsal portion of the exposed pleura and covering the costal half of the tegmina; eyes russet in the male, mars brown in the female; antennæ canary yellow proximad, suffused with dull brown distad in the male, in the female ochraceous, slightly darkened distad. Ventral portion of the lateral lobes very dull olive-yellow in the male, slightly buffy in the female. Sutural half of the tegmina paris green. The two proximal abdominal segments are clouded with blackish in continuation of the dark coloration of the tegmina; dorsum of the two apical abdominal segments, furcula, a broad margin to the supra-anal plate, the margin of the subgenital plate except the apex and the distal half of the cerci blackish brown. Limbs apple green, the caudal femora slightly yellowish proximad and ventrad, the distal extremity blackish, the dorsal face and pregenicular region oil green; caudal tibiæ bottle green, blackish proximad and distad, the spines almost entirely black.

*Measurements.*

	Male.	Female.
	<i>mm.</i>	<i>mm.</i>
Length of body.....	19	22.5
Length of pronotum.....	4.3	4.5
Length of tegmen.....	3.2	3.6
Length of caudal femur.....	12.6	13.1

The typical pair are the only specimens of the species in the collection.

Genus *OSMILIA* Stål.

*OSMILIA FLAVO-LINEATA* (De Geer).

Pernambuco, Brazil. January 4, 1883. (A. Koebele.) One female.

*OSMILIA VIOLACEA* (Thunberg).

Rio de Janeiro, Brazil. November. (H. H. Smith.) One male, three females.

Chapada, Matto Grosso, Brazil. April. (H. H. Smith.) One male.

Genus *POLYCHITONACRIS*,<sup>a</sup> new name.

1859. *Polysarcus* SAUSSURE, Revue et Magasin de Zoologie, 2me ser., XI, p. 392.  
(Not *Polysarcus* Fieber, Lotos, III, p. 175, 1853.)

*Type*.—*Polysarcus atavus* Saussure.

<sup>a</sup> Πολυχίτων, signifying wearing many tunics; ακρίς, signifying grasshopper.

POLYCHITONACRIS ATAVA (Saussure).

1859. *P[olysarcus] atavus* SAUSSURE, Revue et Magasin de Zoologie, 2me ser., XI, p. 393. [Bahia, Brazil.]

Minas Geraës, Brazil. [Hebard collection.] One female.

Rio de Janeiro Brazil. November. (H. H. Smith.) Two females.

The Minas Geraës specimen is somewhat smaller than the Rio de Janeiro individuals, and has the second pronotal lobe not quite as distinctly separated from the third or the spine at the apex of the caudal femora as long. The size of all the individuals is greater than the original measurement given by Saussure ("Long., 0.022"), but otherwise they do not appear separable from true *atava*.

The measurements are as follows:

	Minas Geraës.	Rio de Janeiro.	
	mm.	mm.	mm.
Length of body (including ovipositor jaws) .	27	29.8	34.7
Length of pronotum . . . . .	8	8.1	8
Greatest width of dorsum of pronotum . . . . .	7.8	8.6	8.3
Length of caudal femur . . . . .	17	19	18.2



DESCRIPTIONS OF THREE NEW SPECIES OF CISCO, OR  
LAKE HERRING (*ARGYRO SOMUS*), FROM THE GREAT  
LAKES OF AMERICA; WITH A NOTE ON THE SPECIES  
OF WHITEFISH.

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*President, Stanford University, California,*

and

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In the investigations of the fisheries of the Great Lakes system by the International Fisheries Commission of Great Britain and the United States during the summer of 1908, three new species of the genus *Argyrosomus*, known as Cisco or Lake Herring, were obtained. These are described in the present paper.

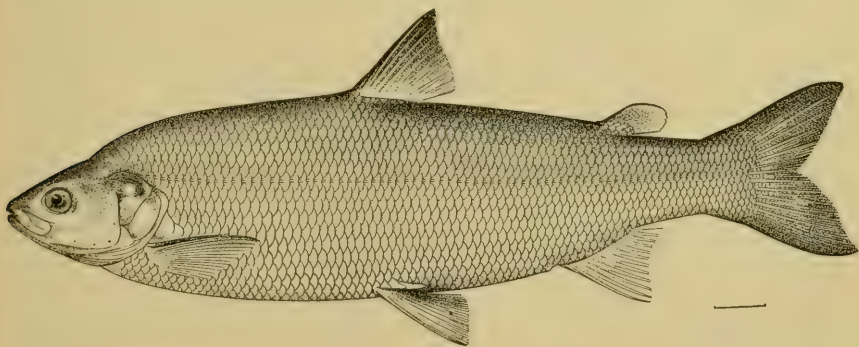


FIG. 1.—*ARGYROSOMUS ERIENSIS*.

*ARGYROSOMUS ERIENSIS* Jordan and Evermann, new species.

JUMBO HERRING OR ERIE CISCO.

Head  $4\frac{2}{5}$  in the length, measured to base of caudal; depth  $3\frac{2}{5}$ ; depth of caudal peduncle  $2\frac{1}{5}$  in head; eye  $5\frac{1}{5}$ ; snout  $3\frac{3}{4}$ ; interorbital space  $3\frac{1}{4}$ ; length of maxillary from tip of snout 3; D. 10; A. 12; scales in lateral line 71; between lateral line and origin of dorsal 8; between occiput and dorsal 32.



Body very deep, its width contained  $1\frac{2}{5}$  times in head; dorsal outline curved abruptly upward behind occiput; dorsal contour of head straight; snout pointed, though rather blunt at tip; jaws about equal, the lower closing just beneath the upper at tip; maxillary extending to a point beneath anterior edge of pupil, the supplemental part about 3 times as long as wide. Gillrakers on first arch 16+29, very slender, the longest equal in length to diameter of orbit. Scales firmly attached.

Dorsal inserted about midway between tip of snout and base of caudal, the highest (first) ray contained  $1\frac{1}{2}$  times in length of head; height of adipose dorsal equal to  $1\frac{1}{2}$  times the length of its base; height of anal contained 2 times in length of head; outline of both dorsal and anal slightly concave; origin of ventral below anterior part of dorsal, length of fin contained  $1\frac{1}{2}$  in head; pectoral  $1\frac{2}{5}$  in head.

Color in spirits silvery, dusky on upper parts, but without blue shades in life; distal portion of dorsal, outer part of caudal, and edge and tip of pectoral dusky; other fins white.

*Type*.—Cat. No. 62515, U.S.N.M., is from Lake Erie at Port Stanley, Ontario, measuring  $16\frac{1}{2}$  inches in length, and was collected by the writers. This represents the maximum of the size of the species as seen by us. Its weight when fresh was  $2\frac{3}{4}$  pounds. A cotype,  $14\frac{1}{2}$  inches long, No. 13083, Stanford University collection, obtained at the same time, is a little smaller and slightly darker in color, the anal having a terminal dusky cloud. It has 11 dorsal and 11 anal rays.

This species is very abundant along the northern shore of Lake Erie about the first of August. It is also occasionally taken in the southern part of Lake Huron, but it seems to be unknown in Lake Superior, and we did not hear of it in Lake Ontario. On the date of our visit to Port Stanley, July 29, 1908, about 1,500 pounds were taken in the gill-nets. The largest of these weighed  $2\frac{3}{4}$  pounds, and were about 18 inches in length. The bulk of the catch was, however, about 14 inches in length. It is said of this species that there is a "great spurt" or large run in the spring and a short one in the autumn, before the spawning time in November.

The species was also seen at Port Burwell, where large numbers of them are smoked, having an excellent flavor as thus prepared. Many others from Point Rondeau, Ontario, were seen in the Detroit market.

The species may be called the "Erie Cisco," as it is characteristic of that lake, although other species, *Argyrosomus artedi*, the common Lake Herring, and *Argyrosomus huronius*, are found in the same lake. Fishermen claim that it is found in middle water, not at the surface nor at the bottom. As a food fish it is far superior to any other lake herring, being as delicate and rich in flavor as

the best Whitefish, *Coregonus albus* and *Coregonus clupeiformis*. It is therefore a species worthy of careful attention from the propagators of fish. It is claimed that it is rapidly increasing in abundance and that it was virtually unknown until within the past ten years. Most of the fishermen claim never to have seen examples of 2 to 3 pounds until within four or five years. It is locally known as the "Jumbo Herring," as it reaches a larger size than any other "Lake Herring" except the Tullibee of the northwestern lakes (*Argyrosomus tullibee*).

It is believed by many fishermen that the Jumbo Herring is the product of a cross between the Erie Whitefish (*Coregonus albus*) and the Lake Herring (*Argyrosomus artedi*). This belief is without foundation. It rests on the fact that at the Put-in-Bay Hatchery attempts have been made to fertilize Whitefish eggs with the milt of the Lake Herring, in default of the milt of its own species. To test this matter, Mr. Frank N. Clark, of the hatchery at Northville, Michigan, undertook the same experiment under carefully prepared conditions. In no case was the egg of a Whitefish fertilized by the milt of the Lake Herring, and the hybridization of the two species is quite improbable.

The following are our field notes on this species:

Jumbo Herring, Port Stanley, July 29, 1908. Head  $4\frac{1}{2}$ ; depth  $3\frac{1}{2}$ ; length  $16\frac{1}{2}$ ; scales 7-9-80. D. 2, 9; A. 12. Head much deeper and less pointed than in the Lake Huron herring; lower jaw less projecting, almost even. Maxillary 3 in head. Supplemental maxillary a little narrower than in the other, not twice as long as broad, reaching front of pupil. Eye  $3\frac{1}{2}$  in head. Suborbital to mucous channel, about  $\frac{1}{2}$  as broad as pupil below eye, the whole width of bone not much greater than pupil. Gillrakers about 30 below arch. Color, olive above, sides silvery, a little less bluish than in the other, the stripes on scales much less distinct. Dorsal, pectoral, and caudal edged with black. Ventral without black tips. Caudal peduncle  $1\frac{2}{3}$  in length from adipose. Greatest depth of tail equal to its length. Cooked, the Jumbo Herring is a fine, rich, well-flavored fish, as good as Whitefish. The Lake Huron herring is rather poor and tasteless, though as good as ordinary *artedi*.

ARGYROSUMUS HURONIUS Jordan and Evermann, new species.

#### LAKE HURON CISCO.

Head  $4\frac{2}{3}$  in length to base of caudal; depth  $4\frac{1}{2}$ ; depth of caudal peduncle  $2\frac{9}{10}$  in head; eye 5; snout  $3\frac{2}{3}$ ; interorbital space  $3\frac{1}{3}$ ; length of maxillary from tip of snout 3; D. 9; A. 11; scales in lateral line 80; between lateral line and origin of dorsal 8; between occiput and dorsal 36.

Body notably elongate, elliptical, with slender, pointed head and slender tail, less compressed than in the other species of the genus; head small, the snout long and pointed; lower jaw not closing within the upper, but extending slightly beyond it; maxillary reaching a point below center of pupil, its width contained 3 times in the

length. Gillrakers on first arch,  $10 + 32$ ; very slender, those near angle equal in length to diameter of eye.

Lateral line almost straight. Scales large and rather loosely attached.

Dorsal inserted midway between anterior border of eye and base of caudal; height of first ray contained about  $1\frac{3}{5}$  times in length of head; length of base of adipose dorsal about equal to its height; origin of ventrals below middle of dorsal, the rays slightly shorter than those of dorsal; length of first anal ray,  $2\frac{1}{2}$  in head; caudal deeply forked; pectoral short, about  $1\frac{1}{2}$  in head.

Color in life, clear metallic blue above, silvery below; in spirits, silvery; dusky above, light below; a very indistinct, narrow, dusky stripe along each row of scales on upper half of body; dorsal with a broad dusky margin; caudal largely dusky; a mere trace of dark color on paired fins and the anal.

*Type*.—Cat. No. 62516, U.S.N.M., measures  $14\frac{3}{4}$  inches in length and was taken at Port Stanley, Ontario, by the writers, on July

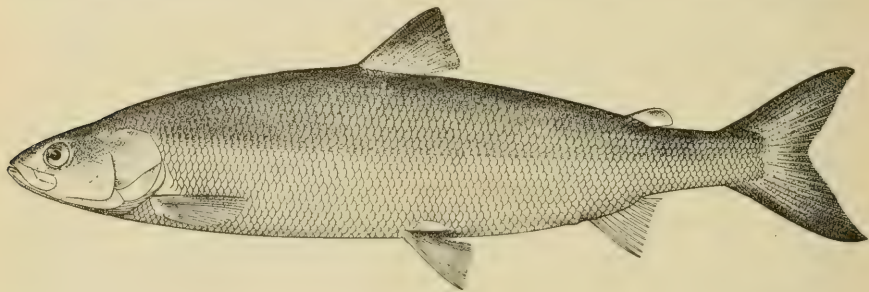


FIG. 2.—*ARGYROSOMUS HURONIUS*.

29, 1908. A cotype, No. 13082, Stanford University collection, measuring 17 inches long, has ten rays in the dorsal and a slightly longer pectoral.

The species is known locally at Port Stanley as Lake Huron Herring, or Blueback. About a dozen were found mixed with about a thousand of *Argyrosomus eriensis*.

The flesh of this species is rather dry and flavorless, something like that of the Menominee Whitefish, *Coregonus quadrilateralis*, and it is not to be compared as a food fish with the Erie Cisco.

The species seems to be quite as common in Lake Huron as is the usual lake herring, *Argyrosomus arctedii*. It has not been noted from Lake Superior or Lake Ontario, in both of which lakes *Argyrosomus arctedii* is abundant. A number of specimens were obtained from off Mackinac, but none of these was preserved. In our field notes is the following account of one of these:

*Argyrosomus huronius*, a lake herring called Blueback, taken off Mackinac Island, by Leggett, a fisherman at Mackinac, August 3, 1908.



Length  $13\frac{3}{8}$  inches; head  $4\frac{1}{4}$ ; depth  $4\frac{3}{8}$ ; eye  $4\frac{1}{2}$  in head; maxillary to end of snout  $3\frac{1}{2}$ ; maxillary proper  $3\frac{1}{4}$ ; supplemental maxillary with broad hook, and more than twice as long as broad; maxillary barely reaching front of pupil; snout  $3\frac{3}{8}$ ; jaws equal at tip; chin projecting; scales, 8-78-8; gillrakers, 14+29. Pectoral  $1\frac{1}{2}$  in head; dorsal  $1\frac{1}{4}$ ; dorsal rays 10; anal 10.

Color dark olive with bluish luster above and sparse dark points on scales; tip of jaws dark; dark spot on preopercle as in the other species; edge of all fins dusky; maxillary rather dark; caudal slender, least depth less than half, its greatest depth a little more than half length.

This seems to be the same as the Lake Huron herring we got at Port Stanley. Maxillary barely to front of pupil.

The following field notes were taken in Lake Erie:

Lake Huron Herring, Port Stanley. Specimen 18 inches long. Head  $5\frac{1}{4}$ ; depth 5; scales 8-10-83. Dorsal 10; anal 10. Body elongate, lanceolate, not much compressed. Head pointed, lower jaw distinctly projecting. Maxillary  $3\frac{1}{2}$  inches head, reaching front of pupil. Eye  $4\frac{1}{2}$  in head. Snout  $3\frac{1}{4}$ . Maxillary on level of pupil. Supplemental maxillary half longer than broad, with a posterior hook. Depth of head under middle of eye  $\frac{1}{2}$  length of head. Sub-orbital to mucous channel nearly as broad as pupil. The bone  $\frac{2}{3}$  of breadth of eye. Pectoral  $1\frac{1}{2}$  in head; ventral  $1\frac{1}{4}$ ; dorsal  $1\frac{1}{2}$ .

*Color*.—Olive sides, very silvery, with lighter streaks along rows of scales. Dorsal, anal, pectoral, caudal, and ventral edged with blackish (smaller fish with the ventrals white). Depth of caudal peduncle at base of fin 2 in length from adipose fin. Gillrakers about 35 below angle. Greatest depth of tail  $1\frac{3}{5}$  in its length.

This differs from the Jumbo Herring in being more slender, less compressed, with slimmer, more pointed head, narrower and much more projecting lower jaw, and much slimmer and rounder caudal peduncle.

ARGYROSOMUS ZENITHICUS Jordan and Evermann, new species.

#### LONGJAW OF LAKE SUPERIOR.

Head  $3\frac{1}{2}$  in length to base of caudal; depth  $4\frac{3}{8}$ ; depth of caudal peduncle  $3\frac{1}{4}$  in head; eye  $5\frac{1}{4}$ ; snout  $3\frac{2}{5}$ ; mouth larger than in related species, almost as large as in *Argyrosomus hoyi*; maxillary to tip of upper jaw  $2\frac{3}{5}$  in head; scales in lateral line 72; between lateral line and base of dorsal 8; between occiput and origin of dorsal 30; D. 10; A. 12.

Form of body elongate, compressed, the width contained about  $2\frac{2}{5}$  times in the length of head; snout pointed; jaws equal in length, the lower usually closing with the upper lip, as in *A. hoyi*. Maxillary extending to a point below center of pupil, the supplemental part wider than that below it. Gillrakers on first arch 17+25; very slender; the longest contained 6 times in the length of head.

Origin of dorsal midway between tip of snout and base of caudal, its height contained  $1\frac{2}{3}$  times in length of head; base of adipose dorsal less in length than height, the height about equal to diameter



of orbit; caudal deeply forked, the lobes equal; length of fin about an eye's diameter less than length of head; height of anal contained  $2\frac{1}{2}$  times in length of head; ventrals inserted below middle of base of dorsal; length  $1\frac{3}{5}$  in head; pectorals unusually long,  $1\frac{1}{2}$  in head, reaching considerably more than half way to anal.

Color silvery; dusky above; dorsal, caudal, pectorals, and anal more or less suffused with black toward the borders, the anal much lighter than the others. Ventrals immaculate; none of the fins wholly black, as in *Argyrosomus nigripinnis*. Scales loose, falling readily.

*Type*.—This description is taken from the type, Cat. No. 62577, U.S.N.M., a specimen 330 mm. long. It was obtained in Duluth, Minnesota, by Mr. John Coventry, of Booth and Company, in September, 1908, it having been taken in deep water off Isle Royale. A cotype, No. 13084, Stanford University, of the same size, and taken at the same time and place, is apparently like the type, in all essential

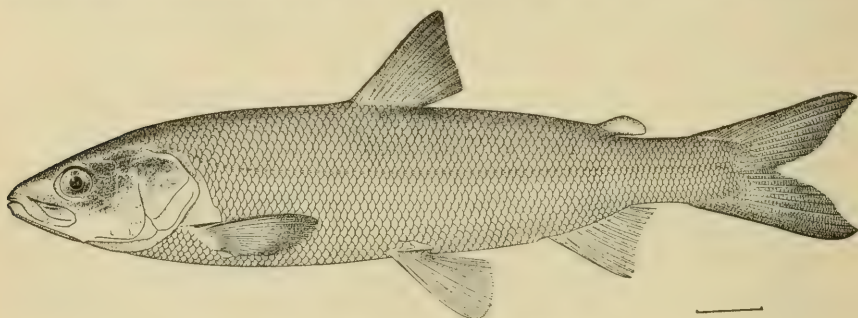


FIG. 3.—*ARGYROSOMUS ZENITHICUS*.

details. Hundreds of specimens of this species were seen in the cold-storage plant of Booth and Company, at Duluth, "the Zenith City."

*Argyrosomus zenithicus* lives in much deeper water than the ordinary lake herring, and makes a part of the autumn catch in deep water. A large part of this catch, however, is of another species, apparently undescribed, called the Bluefin. The present species is locally known as Longjaw, and is more or less confounded by the fishermen with the true Bluefin, which seems to be an ally of *Argyrosomus prognathus*, and with the Mooneye Cisco, Chub, Longjaw, or Kieye (*Argyrosomus hoyi*), which occurs in Lake Michigan and Lake Huron, but which we did not see in Lake Superior.

From the Mooneye Cisco, *Argyrosomus hoyi*, as seen in Lake Michigan, the Lake Superior Longjaw differs in being less silvery in color, with the scales thinner, looser, and more dotted with black; in having a much longer pectoral, in the longer head, longer jaws, and larger adipose fin. The Blackfin Cisco, of Lake Michigan, *Argyrosomus nigripinnis*, has the fins all black, the head shorter, the jaws shorter, and the snout shorter. The pectoral is long in both species.

The Bluefin above mentioned is also a deep water Cisco, with the body robust and the scales firm; head  $4\frac{1}{2}$  in length; depth  $3\frac{3}{4}$ ; maxillary reaching front of eye,  $2\frac{3}{4}$  in head; fins, pale; the dorsal and caudal with the upper edge of pectoral dusky. The species reaches a larger size than the common herring, the specimen above noted, but not preserved, being  $13\frac{1}{4}$  inches in length. Having no specimens at hand, we refrain from naming this species. The Bluefin is not a good food-fish, being rather poor and dry, the flesh rather soft.

The Longjaw, described as *Argyrosomus zenithicus*, is a good fish for smoking. The flesh is soft, but it has a delicate flavor when fresh, though poor and bony after freezing.

#### NOTE ON THE SPECIES OF WHITEFISH.

In this connection it may be noted that the common Whitefish of Lake Superior is the species called Labrador Whitefish, *Coregonus labradoricus* Richardson, characteristic of the Lake of the Woods and of the Canadian lakes generally, and that it is apparently distinct from the Whitefish of Lake Erie and Lake Ontario.

The Lake Superior Whitefish was first named *Salmo clupeaformis* by Mitchill, whose specimens came from the Sault Sainte Marie. Only the Labrador Whitefish is found at Sault Sainte Marie, where it was formerly netted or speared in large numbers by the Indians and where it still readily takes the hook. Large numbers are hooked every day, in the locks of the ship canal, by local anglers. The Erie Whitefish does not take the hook. The technical differences separating the two species are slight, but apparently constant.

Mr. Harry Marcks, director of the fish hatchery at Sault Sainte Marie, tells us that the eggs of the Superior Whitefish are different from those of the Lake Erie Whitefish, being larger and darker in color. The fry are also distinguishable, those of the Superior Whitefish being much livelier and having two dark lines along each side.

The Lake Superior Whitefish must therefore stand as *Coregonus clupeaformis* (Mitchill), or *clupeiformis*, if we demand correct spelling. The Whitefish of Lake Erie is *Coregonus albus* Le Sueur. The Whitefish seen by us in Georgian Bay and a series received from Cheboygan in Lake Michigan belong to *Coregonus clupeiformis*. The same species is found in Rainy Lake, Lake of the Woods, and Lake Winnipeg.

The synonymy of the two species should stand as follows:

#### COREGONUS CLUPEAFORMIS (Mitchill).

*Salmo clupeaformis* MITCHELL, Amer. Monthly Mag., II, 1818, p. 321; Sault Sainte Marie.

*Coregonus labradoricus* RICHARDSON, Fauna Bor.-Amer., III, 1836, p. 206; Musquaw River, Labrador.

*Coregonus sapidissimus* AGASSIZ, Lake Superior, 1850, p. 344; Lake Champlain "type," after Thompson; and Lake Superior.

- Coregonus latior* AGASSIZ, Lake Superior, 1850, p. 348; The Pic, Lake Superior.  
*Coregonus neohantoniensis* PRESCOTT, Amer. Journ. Sci. Arts, XI, 1851, p. 342;  
Lake Winnipiseogee, New Hampshire.

COREGONUS ALBUS (Le Sueur).

- Coregonus albus* LE SUEUR, Journ. Acad. Nat. Sci. Phila., I, 1818, p. 231; Lake  
Erie.  
*Coregonus otsego* CLINTON, Med. and Phil. Register, III, about 1824, p. 188;  
Otsego Lake, New York.

## THE ISOPOD CRUSTACEAN, *ANCINUS DEPRESSUS* (SAY).

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In 1818, Thomas Say<sup>a</sup> described the form which he referred to the genus *Næsa*, as *N. depressa*. A single dried specimen of this species is to be found in the Academy of Natural Sciences in Philadelphia which I have had an opportunity to examine, and which I<sup>b</sup> redescribed and figured in 1905. Another dried specimen of this species is to be found in the British Museum, which, according to White<sup>c</sup> and Hansen,<sup>d</sup> was presented to that museum by Thomas Say.<sup>e</sup>

In 1840, Milne Edwards<sup>f</sup> redescribed *N. depressa*, and instituted for it the new genus *Ancinus*. The footnote given by Milne Edwards for *Ancinus depressus* reads as follows:

*Næsa depressa* Leach, Collections du Musée britannique de Londres. Cette espèce nous paraît être la même que celle décrite sous ce nom par Say (Journal of the Academy of Philadelphia, I, p. 483.)

It is probable that Milne Edwards did not know that this specimen had been presented by Say, and therefore referred it to Leach.

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<sup>a</sup> Journ. Acad. Nat. Sci. Phila., I, 1818, pp. 483-484.

<sup>b</sup> Bull. U. S. Nat. Mus., No. 54, 1905, p. 272.

<sup>c</sup> List of the Specimens of Crustacea in the Collection of the British Museum, 1847, p. 105.

<sup>d</sup> Quart. Journ. Micr. Sci., XLIX, 1905-6, new ser., p. 132.

<sup>e</sup> Dr. Hansen says of this specimen: "The specimen named seems to be the only one existing in any zoological museum; at least I have asked for material of this form in Paris and in American museums, but with negative results." When I asked for Say's types at the Academy of Natural Sciences of Philadelphia I was told that they were not there, but on one occasion, when I happened to be at the museum, I accidentally discovered them.

<sup>f</sup> Historie des Crustacés, III, 1840, pp. 225-226.



In 1905, Tattersall<sup>a</sup> follows Milne Edwards in referring *Næsa depressa* to Leach. Leach, however, never described this form, the earliest description having been given by Say in 1818, and the next to follow being that of Milne Edwards in 1840. Tattersall says of this species (p. 65) in connection with remarks on the distribution of *Bathycopea typhlops*, an allied form:

It is to be regretted that the locality of *Ancinus depressus* Leach is unknown. It would have been interesting to have compared the habitats of the two forms.

Milne Edwards also says of *Ancinus depressus* "Patrie inconnue." Say gives the locality of the specimen of *Ancinus depressus* placed in the Academy of Natural Sciences of Philadelphia as Egg Harbor, New Jersey. White mentions North America as the habitat of the specimen presented by Thomas Say to the British Museum.

In 1905, Tattersall instituted the family *Anciniidae* for the reception of this genus and his new genus *Bathycopea*. In the same year Hansen created the section *Ancinini* of the *Spharominae platybranchiata* to include this genus, as well as his new genus *Ancinella* and *Tecticeps* Richardson. *Ancinus* differs, however, from any of the genera mentioned in the character of the first and second pairs of pleopoda, the first of which are single branched instead of double branched.<sup>b</sup> For this reason it can not be left where it has been placed in the classifications proposed by these authors.<sup>c</sup>

Last spring in the material that came to the U. S. National Museum from Prof. A. E. Verrill was a single specimen of *Ancinus depressus*, collected at Woods Hole, Massachusetts, in 1885, by the U. S. Bureau of Fisheries steamer *Albatross*. It was found at a depth of 2-3 fathoms. The specimen is a female and, although it differs slightly from the figures given by Milne Edwards for this form, I am inclined to think that the differences are perhaps sexual. The uropods are slightly shorter and the first pair of legs have the hand more enlarged. In the shorter uropoda, however, it agrees with the dried specimen in the Academy of Natural Sciences of Philadelphia.<sup>d</sup> As no complete figure has ever been given since that of Milne Edwards, I have thought it would be of interest to figure and redescribe this specimen, which has been preserved in alcohol, and also give some detailed drawings of parts which it has been impossible to study in the dried specimens.

<sup>a</sup> Fisheries Ireland Sci. Invest., 1904, II, 1905, p. 11.

<sup>b</sup> See description and figures which are to follow.

<sup>c</sup> I prefer to retain *Ancinus* as the type and only genus of the family *Anciniidae*, but those who desire to follow the classification of Hansen may accept the name *Spharominae colobranchiata* for a fourth group to include this form.

<sup>d</sup> See figure in Bull. U. S. Nat. Mus., No. 54, 1905, p. 272.

*ANCINUS* Milne Edwards, 1840.*ANCINUS DEPRESSUS* (Say).

*Næsa depressa* SAY, Journ. Acad. Nat. Sci. Phila., I, 1818, pp. 483-484.—RICHARDSON, Amer. Nat., XXXIV, 1900, p. 224; Proc. U. S. Nat. Mus., XXIII, 1901, p. 537.

*Ancinus depressus* MILNE EDWARDS, Hist. Nat. Crust., III, 1840, p. 226, pl. XXXII, figs. 17-20.—HANSEN, Quart. Journ. Micr. Sci., 1905-6, p. 132.—RICHARDSON, Bull. U. S. Nat. Mus., No. 54, 1905, pp. 271-272, fig. 282.—TATTERSALL, Fisheries, Ireland, Sci. Invest., 1904, II [1905], p. 11-18, 65.

Body oblong ovate, twice as long as wide,  $6\frac{1}{2}$  mm. by  $12\frac{1}{2}$  mm. Surface smooth, punctate, and with a few markings. Color, in alcohol, whitish.

Head very wide, much wider than long,  $1\frac{1}{2}$  mm. by  $5\frac{1}{2}$  mm.; it is wider anteriorly than posteriorly, the antero-lateral angles being produced in a lateral direction and forming acute angles. The post-lateral angles are rounded. The anterior margin is produced in the middle in a broad, quadrangular process between the basal articles of the first pair of antennæ, and extends forward to the outer margin of these articles. It meets the frontal lamina at its anterior extremity. The eyes are round, composite, and situated close to the posterior margin of the head, but at a distance from the post-lateral angle equal to the width of one eye. The head is coalesced with the first thoracic segment about the middle, but the sides are free. The first pair of antennæ have the basal article large, about twice as long as wide; the second article is half as long as the first; the third article is narrower than either of the first two and is one and a half times as long. The flagellum is composed of nine articles and extends to the posterior margin of the second thoracic segment. The second pair of antennæ have the first article of the peduncle extremely short; the two following are subequal and but little longer than the basal article; the fourth and fifth are also short and subequal, being but little longer than the two preceding ones; the flagellum is composed of nine articles and extends to the posterior margin of the first thoracic segment.

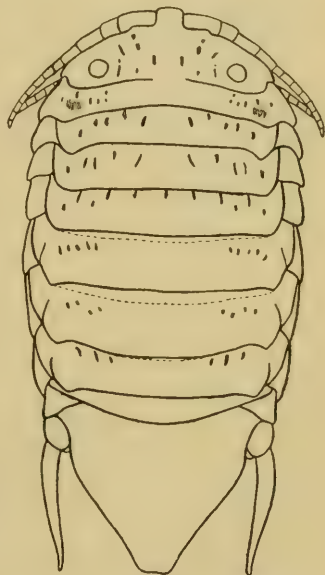


FIG. 1.—*ANCINUS DEPRESSUS*.  
× 14½.

<sup>a</sup> All former measurements were taken from a half-millimeter scale, and should be changed from millimeters to half millimeters.

The maxillipeds have the second, third, and fourth articles of the palp produced into lobes or processes. The mandibles have no masticatory process; the cutting edge is provided with four large blunt



FIG. 2.—*ANCINUS DEPRESSUS*.  
MAXILLIPED.  $\times 77\frac{1}{2}$ .

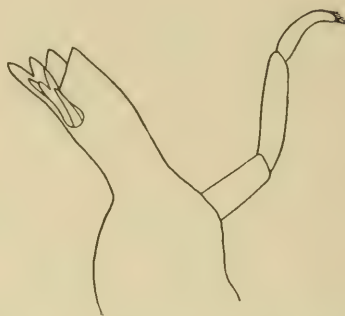


FIG. 3.—*ANCINUS DEPRESSUS*. MAN-  
DIBLE.  $\times 77\frac{1}{2}$ .

teeth; below the cutting edge is a process provided at the tip with three teeth; below this process is a long spine.

The first two segments of the thorax appear to be a little shorter than those following, which are subequal in length. All are of nearly

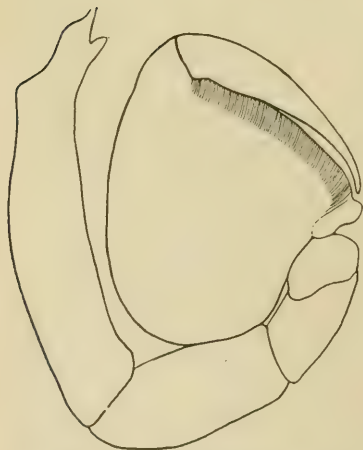


FIG. 4.—*ANCINUS DEPRESSUS*. FIRST  
PAIR OF LEGS OF FEMALE.  $\times 77\frac{1}{2}$ .

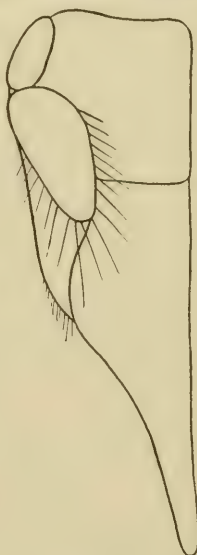


FIG. 5.—*ANCINUS DEPRESSUS*. FIRST  
AND SECOND PLEO-  
POD.  $\times 41$ .

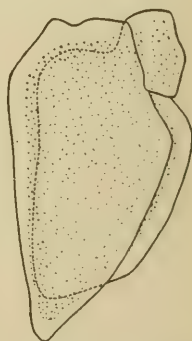


FIG. 6.—*ANCINUS DEPRESSUS*. THIRD  
PLEOPOD.  $\times 41$ .

equal width, the sides of the body being almost parallel. With the exception of the first, the epimera of all the segments are distinctly separated; they are broad, quadrangular plates with the post-lateral

angles more or less produced, and they are all bent downwards about the middle almost at right angles with the segments. On the ventral side they are also produced in the form of a plate, covering the proximal extremity of the legs.

The abdomen is composed of two distinct segments. The first is short, not as long as the last thoracic segment, and has no suture lines indicating other coalesced segments. The terminal segment is triangular in shape with the apex appearing somewhat truncate, owing to the sides of the segment being turned downward and inward, so that on the ventral side a funnel-like opening is formed. The uropoda are composed of a small rounded peduncle and a single slender,

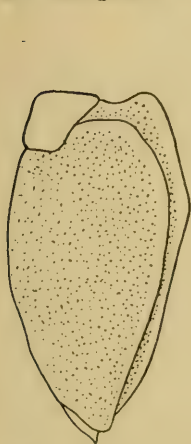


FIG. 7.—*ANCINUS DEPRESSUS*. FOURTH PLEPOD.  $\times 41$ .



FIG. 8.—*ANCINUS DEPRESSUS*. FIFTH PLEPOD. OUTER BRANCH.  $\times 41$ .

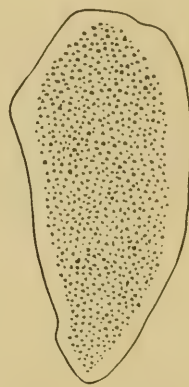


FIG. 9.—*ANCINUS DEPRESSUS*. FIFTH PLEPOD. INNER BRANCH.  $\times 41$ .

movable branch, tapering and acute at the extremity. This branch extends to the extremity of the last abdominal segment.

The first pair of legs are subschelate and have the propodus very much enlarged. All the other legs are ambulatory.

The first pair of pleopoda are small, longer than wide and composed of a single branch furnished with long hairs. This branch is widely separated from the corresponding branch of the opposite side. The second pair of pleopoda are large, double branched, the two branches being placed side by side and attached to the peduncle, so that a sort of operculum is formed, completely covering the following pleopoda. The third pleopoda have the endopod slightly longer than the exopod; both branches without marginal setæ. Fourth pleopoda with endopod and exopod of nearly equal length, and without marginal setæ. Fifth pleopoda with both branches unjointed and without marginal setæ.

Owing to the difference in the structure of the pleopoda, this genus remains alone the type of the family *Anciniidae*. *Bathycopea* Tattersall cannot be retained in the family.





## A NEW AMERICAN JURASSIC CRINOID.

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By FRANK SPRINGER,  
*Of East Las Vegas, New Mexico.*

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The first specimen of a fossil species of Pentacrinidæ from American rocks was described by Meek and Hayden in 1858,<sup>a</sup> under the name *Pentacrinites asteriscus*, from some isolated stem joints found in the Jurassic near the southwest base of the Black Hills of Dakota. They afterwards redescribed and figured the species in their work on the Palæontology of the Upper Missouri.<sup>b</sup> Their figures on Plate 3 were based upon the original specimen; but on page 67 the authors gave a text figure, not very accurate, of some stem fragments with cirri attached, which they referred with doubt to their species. This specimen, according to the label in the U. S. National Museum, came from Red Buttes, Nebraska, a locality now included in the State of Wyoming. The description was stated by the authors to apply "more particularly to the largest sized specimens," which came from a different locality, and which, as represented by the figures on Plate 3, were considered by Dr. P. H. Carpenter<sup>c</sup> to belong to the genus "*Extracrinus*" (*Pentacrinus*, *sensu str.*), although he perhaps based his opinion rather upon the figures given by White<sup>d</sup> of a specimen from Utah than upon those of Meek and Hayden. So far as can be judged from a few isolated joints, there is reasonable ground to believe that the doubt expressed by the authors as to the specific identity of the two specimens is well founded; those of the typical form are nearly twice as large as the others, and the petaloid sectors on the articular face are more sharply angular. The transverse view given in the text figure on page 67 of the work cited is not correct, the structure being rather poorly

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<sup>a</sup> Proc. Acad. Nat. Sci. Philadelphia, X, p. 49; XII, 1860, p. 419.

<sup>b</sup> Smithsonian Contributions to Knowledge, No. 172, 1865, p. 67, pl. III, figs. 2 a, b.

<sup>c</sup> Challenger Report, Stalked Crinoids, pp. 143, 297.

<sup>d</sup> Wheeler, Geol. & Geog. Surv., IV, p. 162, pl. XIII, fig. 6 a.

defined in the specimen. The Red Buttes specimen shows a rather obtusely pentangular, smooth stem, with straight sides, having eleven or twelve joints to the internode, and cirri tapering rapidly near the proximal end.

Separate stem joints, more or less similar to both of Meek and Hayden's figures, have since been collected by the staff of the U. S. Geological Survey in various localities throughout the Rocky Mountain and Pacific regions, but no vestige of the crown was obtained until 1899, when the late Prof. W. C. Knight, of the University of Wyoming, in the course of some investigations among the famous Dinosaur beds near Medicine Bow, Wyoming, discovered some small slabs of limestone containing numerous stems and fragments of arms, with one very complete crown. This he reported as *Pentacrinus asteriscus*.<sup>a</sup> In the following year Mr. H. T. Martin, of the University of Kansas, visited the Medicine Bow locality and succeeded in finding a few more pieces of the rock containing the crinoid remains, which by careful cleaning have yielded some additional specimens useful for description. Through the obliging courtesy of these gentlemen this material was placed in my hands, but pressure of other matters has prevented the preparation of the necessary figures for their description until now.

The locality of these fossils is in the same region and horizon as Meek and Hayden's Red Buttes specimens, and they probably belong to the same species. Assuming, for the reasons already given, that they are not included in the typical *Pentacrinites asteriscus*—of which in any event we know nothing beyond the form and size of separate stem joints—it seems proper to describe this form as a new species. I therefore propose to associate with it the name of the lamented geologist to whose researches we are indebted for its discovery.

ISOCRINUS KNIGHTI, new species.

1865. ? *Pentacrinites asteriscus* MEEK and HAYDEN, Pal. Upper Missouri, p. 67, text fig. (not pl. III, figs. 2 a. b.)

Specimens of moderate size.

Stem smooth, long, slightly increasing in diameter distally; pentagonal with straight sides, except at the proximal end, where for the first few immature internodes the younger joints are stellate. Internodals about 14, but varying from 12 to 17 in the mature parts; distinctly crenulated at the margins; nodals not enlarged, scarcely distinguishable from the others except by the cirrus sockets; these are rather shallow, not extending to the hypozygal, or infranodal joint, but usually encroaching upon the supranodal, in which case the apposed faces of these two joints are more or less indented, producing

<sup>a</sup> Jurassic Rocks of Southwestern Wyoming. Bull. Geol. Soc. America, XI, p. 377.

a marked stellate outline. Conformably to this structure the cirri are directed upward. Interarticular pores extending to the fifth internode. Cirri in whorls of five; round, long, and slender, composed of 40 joints or more; the proximal ones relatively short and broad—about one-third as long as wide—tapering rapidly to about half their breadth, and doubling in length in the first 8 or 10 joints, beyond which they continue uniformly about as long as wide to the end; terminal claw not preserved. Angles of stem interrarial; cirri radial; axial canal in stem small, obtusely pentagonal, and apparently interrarial in position.

Cup forming a low cone, without any downward projection of basals or radials. Infrabasals well defined, filling half the diameter of the column facet and entirely covered by the proximal columnal. Basals large, smooth, visible in pentagonal outline, and in full contact exteriorly by their lateral faces; they form a closed ring, not protuberant but flush with the plane of the radials, and about equal to them in height. Radials forming also a ring continuous with basals. Primibrachs two, united by articulation apparently bifascial. Arms simple, or bifurcating once from the sixteenth to the thirtieth IIBr, thus varying from 10 to 20; they are long, slender, with strongly oblique articulating faces, and they extend to upward of 90 brachials. Syzygies at IIBr 3+4, and beyond throughout the arm at intervals of about 5 to 10 brachials. Pinnules long, rounded, composed of elongate joints, 15 or more in the distal pinnules, but the number in the proximal ones not observable. Disk unknown.

*Dimensions of mature individual.*

	mm.
Height of crown-----	65
Width of axillary IBr-----	7
Height of axillary IBr-----	5
Length of cirrus of 40 joints-----	32
Length of longest stem preserved-----	140
Diameter of stem at second internode-----	2
Diameter of stem at tenth internode-----	25
Diameter to height of second internode-----	1-2.2
Diameter to height of tenth internode-----	1-5.2
Diameter of stem to length of longest cirrus-----	1-17

*Horizon and locality.*—In the Shirley stage of the uppermost Jurassic. Medicine Bow, and Red Buttes, Wyoming.

The occurrence at Medicine Bow was in a band of argillaceous limestone about 1 inch thick, and it is undoubtedly the remnant of a considerable colony. The upper surface of the layer is filled with disintegrated stem joints and brachials closely cemented together, while toward the lower part the crinoids had been embedded as they perished without much disturbance. Unfortunately the layer was



not found *in situ*, all the specimens being derived from small, loose pieces in the débris. Most of the crinoids are therefore broken and imperfect, and only a few preserving parts of the arms and column were recovered. The most complete is the one given me by Professor Knight (Plate 4, fig. 1). Unfortunately the structure was not understood when found, and the stem of this specimen was almost stripped of its cirri by too energetic cleaning in the field; most of those on specimen No. 2 had been removed by weathering, but by careful manipulation of the embedded proximal part of this stem and of some other stem fragments I have developed the cirri so that their length and proportions can be ascertained.

The form under consideration is clearly distinct from species like *Pentacrinus fossilis* and *P. subangularis*, in which the radials project downward over the proximal columnals, and to which type only, as clearly pointed out by Doctor Bather, in his paper on "*Pentacrinus*, a Name and its History,"<sup>a</sup> the name *Pentacrinus* properly belongs. But it falls readily under the genus *Isocrinus* (Agassiz, 1836).

A brief excursion among original sources enables me to add a little to the very elaborate and instructive history of these names given by Bather in the work cited. *Isocrinus*, although described by von Meyer in 1837, as stated, was actually published as a generic name by Agassiz in 1836.<sup>b</sup> Speaking of this form, Bather says on page 250 that "no figure of a fossil crinoid of our type *C* (*Isocrinus*) is known to me before 1800." In an extensive work by Daniel Brückner, entitled "Versuch einer Beschreibung historischer und natürlicher Merkwürdigkeiten der Landschaft Basel," published in 23 parts, or "Stuecke," from 1749 to 1763, there is on pages 2425-2431 of the twentieth Stueck a good figure—No. 37—of a well-preserved specimen of this type, from the Swiss Jura, showing arms, stem, and cirri, accompanied by a long description and a name. The original specimens have been refigured by de Loriol in his "Crinoides de la Suisse," Plate 14, figs. 31-38, under the name *Cainocrinus andreae* Desor, a genus since considered by him to be identical with *Isocrinus*. The twentieth Stueck of Brückner's work was published in 1761, and to the crinoid figured and described as above stated he gave the name *Entrochites ramosus*, vel *Eucrinus*, *Lilium marinum*. So not only was the type figured and described before 1800; but a name was given to it in binomial form, thus raising the question whether the real name of our genus is not the venerable and classic term *Entrochites*, thus for the first time brought into the domain of valid nomenclature.

<sup>a</sup> Natural Science, April, 1908, p. 252.

<sup>b</sup> The Nomenclature of the Recent Crinoids. Austin H. Clark, Proc. U. S. Nat. Mus., XXXIV, 1908, p. 526.

However, Brückner did not employ binomial names consistently, many of those relating to crinoidal remains being polynomial, as, for instance, *Entrochites fungita adharens*, eighth Stueck, page 888; *Eucrini minoris pulcre ramificatum*, etc.; and his incidental use of *Entrochites ramosus* may probably be disregarded for that reason.

The case of *Eucrinus* is much more serious. Bather credits it to Schulze (1760), who wrote it "*Eucrinum*," probably as the accusative of *Eucrinus*. Schulze's work was mainly a compilation from former authors, as Linck, Lhuyl, Seba, and Ellis, and he uses their names in the same manner as they did, with but small pretense to binomial application. He did not propose *Eucrinum* to represent a genus, but only mentioned by way of recital the fact that certain petrifications resembling a lily have been called the lily stone, *Eucrinum*. This is what he says: "Man findet eine gewisse Versteinerung, die, in Ansehung ihrer Gestalt, einige Gleichheit mit einer Lilie zu haben scheint; daher man dieselbe anfänglich für die Versteinerung dieser Blume gehalten, und sie den *Lilienstein*, *Eucrinum*, genennet hat."<sup>a</sup>

On Plate 4 is a figure of a complete crown of the fossil to which he refers, and in the long description which follows he mentions it four times by the name "*Lilienstein*," but never again as *Eucrinum*. It seems to me there would be as much reason for recognizing as valid names the *Decacrimos* (= *Antedon*) and *Triscadecacrimos* (probably = *Comatula*) which he transliterates from Linck, because it was the first post-Linnaean use of them, as *Eucrinum*, which he recites as an equivalent of the name he actually uses in description—*Lilienstein*. Yet nobody recognizes these names, the ground of their rejection being, I suppose, that they are not binomial, which *Eucrinum* certainly is not. I regret to find myself led to this impression by an inspection of Schulze's work, because there are serious troubles ahead for the name "*Eucrinus*," from which we would be saved but for its doubtful standing there.

The earliest use of the name "*Eucrinus*" in a binomial sense that I know of was by Andreae in his "*Briefe aus der Schweiz*," published in the *Hannoversches Magazin* in 1763-64, and afterwards in book form in 1776. On page 4 of this work he formally proposes the name *Eucrinus coralloides* for certain fossils which appear to him to be a species of *Eucrinus* or *Lilienstein* not before recognized, and which had been figured on Table 8 of the eighth Stueck of Brückner's work above mentioned. He also refers to figures of similar specimens given by Rosinus<sup>b</sup> on Table 10, A, B, C, D, E.

These fossils are now supposed to be the terminal stem branches or roots of *Millericrinus*, and one of them—Brückner's fig. *h*—has been

<sup>a</sup> Betrachtung der Versteinerten See-Sterne und ihre Theile. p. 21.

<sup>b</sup> Testamen de Lithozois, 1718.

referred to *M. echinatus* by de Loriol.<sup>a</sup> Therefore a strict observance of the rule of priority might seem to require us to transfer the name "*Eucrinus*" to the crinoidal remains which we have for three-quarters of a century ignorantly been calling *Millericrinus*, and to relegate to obscurity our still older acquaintance, *E. liliiformis*, until some one introduces it to us afresh under a new name.

But if we hold that Andrea's name was applied to unrecognizable fragments, and for that reason is not valid, our troubles over *Eucrinus* are not ended. The name was used by Blumenbach in 1779 in the first edition of his "*Handbuch der Naturgeschichte*," page 435, in a strictly binomial sense, for a genus with three species, arranged as follows:

ENCRIINUS:

- (1) *asteria* (Linnæus, after Guettard).
- (2) *mylii* (based on Mylius' Greenland specimen—a Pennatulid).
- (3) *boltenii* (based on Boltenius—an Ascidian.)

Here the name is taken out of the domain of Palæontology and applied to a recent crinoid—the type species being Guettard's famous *Palmier marin* of Boisjournain, best known in literature as "*Pentacrinus*" *caput-medusæ*, or in present nomenclature as *Isocrinus asteria* Linnæus.

In the third edition, 1788, Blumenbach again gives the genus *Eucrinus* with *asteria* as the first species; and in 1801 Lamarck, the generally accepted father of *Eucrinus* as now commonly known, in the first edition of his "*Système des Animaux sans Vertèbres*," p. 379, recorded the genus as follows:

ENCRIINUS:

- (1) *caput-medusæ* (= *Isis asteria* Linnæus.)
- (2) *liliiformis*.

No. 2 of Blumenbach was made the type of a new genus—*Umbellaria*, and in 1816 Savigny<sup>b</sup> made Blumenbach's species No. 3 the type of another genus, *Boltenia*. Thus by the year 1816 *Eucrinus* was definitely restricted, by the removal of two of its original three species, to the group with *asteria* as the type. If Blumenbach's name is to stand, the subsequent references of *asteria* to *Pentacrinus* and *Isocrinus* are invalid, and the reference by Lamarck of *liliiformis* to *Eucrinus* must likewise fall to the ground. According to the rules it will have to stand, unless theretofore validly applied to something else; and unless it has been so applied, *liliiformis* can not stand under it.

<sup>a</sup> Crin. de la Suisse, p. 75.

<sup>b</sup> Mem. sur les Animaux sans Vertèbres, p. 140.



The consequences to our literature of a strict application of the rule of priority to either of these nomenclatorial discoveries would be somewhat appalling. Suppose we take—

1. *Encrinus*, Blumenbach, 1779; type, *E. asteria*, which is good unless preoccupied by something earlier. This will require—

a. A new generic name for *Encrinus liliiformis*, which has been used for nearly a century for the best known of all crinoids—one which has been figured and described as such in countless works, and specimens of which are found under that label in all the cabinets and museums of the world.

b. Applying the name, so long associated with the most familiar fossils, to new, different, and unfamiliar use.

c. Supplanting the name *Isocrinus* after it has become thoroughly well established in literature, and is now currently employed by all writers on the recent crinoids.

Or, if we take—

2. *Encrinus*, Andreae, 1776; type *E. coralloides* (= *Millericrinus echinatus*); this, if good, upsets Blumenbach, but does not save us from results equally direful. For it likewise requires us—

a. To provide a new generic name for *E. liliiformis*.

b. To apply the old name, with all its familiar association, to new and different fossil forms, occurring in the same region, well known and abundantly represented in literature under another name for seventy-five years.

c. To give a new name to *Millericrinus*.

This brings us back again to—

3. *Encrinum*, Schulze, 1760; no type-species stated, but the name was probably intended for the fossil commonly known as *E. liliiformis*, which he figured. Schulze's use of the term was not binominal, and the case is a hard one; but he did use some other names binomially, and it may be presumed that he intended to do so with this. To recognize his name as valid would avoid all confusion, and leave the literature as to all three of the names involved undisturbed. And in a case like this, arising in the dawn of our science, before the rules of nomenclature had become formulated, or were even practically thought of, I think that expediency and the question of practical disadvantages or benefits to the scientific public are to be considered where there is a possible alternative and some room for the exercise of discretion. Here, on the one hand, is invited intolerable confusion and the overthrowing of long familiar and classic names to an extent that will bring the rules of nomenclature into disrepute; and this without serving any useful purpose and without benefit to anybody, unless it be the satisfaction of some delver among musty tomes, as I am, in making all the trouble he can. On the other hand, there is the preservation of these names in the sense to which all



general zoologists and palæontologists are accustomed, without injury to anyone, or the infringing of any principle except that of an extreme technical construction of the rules.

The underlying principle of the rule of priority is said, and properly said, to be *fixity*. Yet by insisting upon its absolute and unbending application to all cases, without regard to circumstances, we may destroy the very fixity for which we contend. There is no law more deeply rooted in the foundations of civil government, or more essential to the welfare and stability of society, than that of the fixity of the titles to real estate based on priority. But just as that law in actual administration is subject to exceptions founded upon principles of natural justice and the dictates of public policy, so I think we may find reasonable basis for an exception to the rule of priority in nomenclature which will meet such cases as this.

This would be that such names, irrespective of the actual state of the record as to their dates, should be protected under an exception to the rule, simply on the ground of long use, on the doctrine of prescription, which is a principle well known in law, recognized in continental Europe as coming down from the civil law of Rome, and now embodied in statutes in all English-speaking countries. It is that the right of property will be upheld by the courts in favor of one who can show a long, continuous, and undisputed possession of it, under a claim of right however defective, notwithstanding he has no paper title, and even though the records may show the prior title to be in someone else. This rule of law rests upon the idea that it is for the public interest that there be an end of controversy, and that there shall be some reasonable time after which titles may be held safe from attack on any ground. And this end was attained in the beginning, not by denying or abrogating the law governing the conveyance of property by deeds, but by invoking a simple presumption, founded on the known and usual conduct of men with regard to their interests, that where such long and undisputed possession existed there must have been a good title, the evidence of which is lost.

This principle of jurisprudence is now recognized throughout the civilized world, as one of the most salutary and beneficial provisions for preventing injustice, and insuring that repose of titles which the peace and order of society demand. By virtue of its operation a title by lapse of time merely, if properly proven under all the safeguards which are prescribed in practice to prevent the abuse of it, is as good in the actual possessor as a paper title showing priority by an unbroken chain of recorded deeds. If this be true with regard to matters of such vital importance as the titles to our landed property, why may not the same principle be invoked in favor of repose and stability of names in our scientific literature? It is not a question of "doing justice" to any particular ancient author. The propo-

sition is one of far broader significance, and involves the paramount interest of the scientific public.

I am much in sympathy with the protest voiced by Dr. G. A. Boulenger, at the Dublin meeting (1908) of the British Association, against the extreme application of the rule of priority, where the effect would be, as in this case, to overthrow old and well understood names, or to transfer them from one object to another. He renews a suggestion made by Sir E. Ray Lankester ten years earlier, that there should be created by the International Congress some kind of committee, having the powers of a court of last resort, to decide upon the application of such an exception to the rule of priority in particular cases.

In the meantime, and until overruled by some such higher authority, I shall maintain that, irrespective of the merits of their original titles to priority, the names of *Encrinus* and *Millericrinus* have become valid simply by the lapse of time, by long usage in the sense in which they are now generally understood; and that by reason of universal acquiescence in such use for nearly a century, zoologists are now estopped from disputing them. In this way, by analogy to the practice which prevails in courts of justice touching the most solemn rights of property, a presumably just conclusion can be reached independent of the rule of priority, and without impairing its force in cases to which no such considerations of public policy apply. With these two names thus firmly established, that of *Isocrinus* is *ipso facto* confirmed, and I am enabled to proceed with further comment on the species under consideration, without the necessity of searching for a new generic appellation.

In view of the generally assumed absence of infrabasals in "*Pentacrinus*" (*sensu* P. H. C.) and *Metacrinus* twenty years ago, and in the recent species until the past year, it is interesting to find their presence now fully demonstrated in no less than six species; two fossil—this and de Loriol's *I. leuthardi*—and four recent ones within the past few months. Doederlein described them in *Metacrinus acutus* in November, 1907,<sup>a</sup> and they were independently discovered by Mr. Austin H. Clark, who communicated the facts to me under date of November 29, 1907, in two other species of *Metacrinus*, and also in *Isocrinus decorus*.<sup>b</sup>

The infrabasals in our species were only observable in a single specimen, a rather small individual, in which the stem was broken off at the top joint, by which they had been covered (Plate 4, fig. 5a). As thus exposed they are perfectly distinguishable, and are somewhat larger than those figured by de Loriol.

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<sup>a</sup> Die Gestielten Crinoiden der Siboga Expedition, p. 20.

<sup>b</sup> Proc. U. S. Nat. Mus., XXXIII, p. 671-676.

There can be no longer any doubt that the *Pentacrinidae* are all either actually or potentially dicyclic, though in some species the infrabasals are resorbed at an early stage. This has been shown by Mr. Clark to be the case in *Isocrinus parvæ* (*olim mülleri*),<sup>a</sup> and the observations of P. H. Carpenter (Stalked Crinoids, pp. 292-93) would seem to indicate that a similar condition prevails in *I. wyville-thomsoni*, *I. asteria*, and *I. alternicirrus*. I have found the same thing to be the case also in certain species of the palæozoic genus *Ichthyocrinus*.

As to specific relations, it is impossible, with the material available, to make any very satisfactory comparison with European species, a great many of which have been described from isolated stem joints. Although the stem as a whole often affords valuable characters for distinguishing species among the recent crinoids, and even a part of it, if the same parts can be compared, little reliance can be placed in species whose identification depends wholly upon the form and articular markings of joints whose position in the stem can not possibly be known. This has been pointed out by Carpenter (Stalked Crinoids, pp. 226, 298), and the fact is well shown by his Plate 22, where many different forms of columnals from the stem of *I. wyville-thomsoni* are figured. Mr. Clark has recently found by dissection of the stem of a young *I. decorus*<sup>b</sup> that in the different parts of the same stem may be found almost every type of articular face, from stellate to round, and from a bifascial articulation with transverse ridge as in *Rhizocrinus*, to the radiating petaloid sectors of the usual *Isocrinus* type. Several different forms of stem joint are found in the present species, the more common being obtusely pentagonal, while the younger joints near the calyx become stellate. The proximal face of the nodal joint also shows a sharply stellate outline, due to the indentation by the cirrus sockets (Plate 4, figs. 9, 10, 11, 12, 13). In the associated material are thousands of separate joints, besides several considerable portions of stems intact, and there is a general uniformity of size and appearance among them which indicates their probable derivation from a single species. They are uniformly different from the much larger ones on which *P. asteriscus* was founded, and from the Utah specimen referred by Doctor White to *P. asteriscus*,<sup>c</sup> but afterwards separated from it by Dr. W. B. Clark under the name *Pentacrinus whitei*, because of its alternating joints. Clark's comparison was made chiefly with the Red Buttes specimens of *P. asteriscus* (?), but the separation is doubtless well founded, nevertheless, as the character on which he bases it is clear in his specimen, and can not be shown in the type of *P. asteriscus*. The difference between the stem of our species and that of *P.*

<sup>a</sup> Proc. U. S. Nat. Mus., XXXV, 1908, p. 87.

<sup>b</sup> Idem, XXXV, p. 88.

<sup>c</sup> Bull. U. S. Geol. Surv., No. 97, p. 27.



*whitei* is similar to that between the recent *I. decorus* and *I. parvæ*, which is fairly constant.

The most nearly related European species that I know of is de Loriol's "*Pentacrinus*" *beaugrandi*, from the Upper Jurassic, Portlandian stage, near Boulogne-sur-Mer, France.<sup>a</sup> This was the only Crinoid known to the author from the Portlandian stage, and it is the species which he originally proposed to separate from the other Pentacrinidæ on account of having a closed ring of basals, under the name *Pictetierinus*. In this he found himself anticipated by the *Cainocrinus* of Forbes, and in the work last cited, page 281, he abandoned the distinction, and referred the species to *Pentacrinus* (*sensu* P. H. C.). It has similar large basals, but the arms branch lower down, the stem is more sharply stellate in corresponding portions, and the cirri much more delicate. The stem is preserved to the fourth internode, which has 8 internodals, whereas ours has 14 at the same stage.

*Pentacrinus* (*Cainocrinus*) *andrew* Desor<sup>b</sup> is similar to the French species, but with shorter basals and shorter internodes.

The excellent preservation of our specimens enables us to make an interesting comparison with recent species. The stem has a considerable resemblance to that of *I. decorus*, except in the disposition of the cirri. It must have been quite long, as the longest portion, preserved to a distance of 140 mm., shows little sign of any rounding. It is rather more pentagonal for equivalent distances. The cirri are very long and slender; the taper near the base from short and wide joints to long, narrow, and equal ones, is quite marked. The most perfect one has 44 joints, and this was probably near the maximum. The interesting thing about the cirri, however, is the fact that they are directed upward instead of downward or outward. In consequence the sockets do not extend to the infranodal (hypozygal) joint, but slope upward toward the supranodal, the lower margin of which is often incised by them. This is more or less the case in the genus *Metacrinus*, but is not usual in the recent species of *Isocrinus*, most of which have the cirri directed downward, though in some, as *I. asteria* and *I. wyville-thomsoni*, the socket is confined to the nodal joint, and the cirri are given off about horizontally.

The basals, as shown by the five specimens figured and three others, are quite uniform in their form and proportions. They form with the radials a low funnel, with smooth or slightly rounded sides, and without protuberance or projection of any kind. They are connected exteriorly by their lateral faces, giving a pentagonal outline and forming a closed ring (Plate 4, fig. 3a), as in the type for which Forbes proposed the genus *Cainocrinus*, instead of appearing as mere triangular points separated from each other by the radials, and tend-

<sup>a</sup> Mon. Étage Jur. Boulogne-sur-Mer, 1875, p. 298, pl. xxvi, figs. 23-25; Paléontologie française, Crinoïdes, XI, 2<sup>e</sup> partie, p. 278, pl. clxxxix, figs. 1-3.

<sup>b</sup> De Loriol, Crin. Foss. de la Suisse, p. 112.



ing more or less to project downward over the proximal column joints, as in most recent species.

The bifurcation of the arms so far beyond the axillary IBr is an unusual feature, occurring in the largest specimen at the twenty-seventh to the thirtieth brachial (Plate 4, fig. 1), and in other specimens from the sixteenth to the twenty-third. I know of no Pentaerinoïd in which arm division takes place so high up; nor in fact any inadunate crinoid, the nearest approach to it being found in the Carboniferous genus *Poteriocrinus*. There is little tendency of the arms to spread out, but they are long and slender, tending rather to lie in a bundle. The general aspect of calyx and arms is somewhat like that of *I. navesianus*, which it also resembles in the number and regularity of the syzygies, which is unusual in the Pentaerinoïdæ. I can trace them in two arms of specimen A (Plate 4, fig. 1) part way, and in one to the end, and can distinguish them in the distal portion of some other arms. Beginning at IIBr 3+4, they occur at intervals of mostly about 10 brachials, but sometimes 4, 5, or 6. I give a figure of the pair next to the last, being about brachials 79+80 of that arm. (Plate 4, fig. 1a.)

The type-specimens figured are deposited in the U. S. National Museum, where they will be available for comparison with the magnificent collection of recent crinoids now being accumulated there. For convenience of reference they are designated by the letters, *A*, *B*, etc., as indicated in the explanation of the plate.

#### EXPLANATION OF PLATE 4.

##### *Isocrinus knighti*, new species.

Fig. 1. Large specimen, *A*; with bifurcating arms complete and part of stem; cirri mostly lost.

1a. Syzygy at IIBr 79+80 of same specimen.

2. Large specimen, *B*; with stem 140 mm., and part of arms. Some arms of another individual attached.

2a. Detail of stem at "a" of same specimen, showing interarticular pores,  $\times 2$ .

2b. Detail of same at "b;" showing cirrus sockets,  $\times 2$ .

3. Small specimen, *C*; with part of arms, some not bifurcating.

3a. Calyx and lower IIBr of same specimen; showing form and proportions of basal and radial plates,  $\times 2$ .

4. Small specimen, *D*; with part of arms, one with an axillary, and some apparently simple.

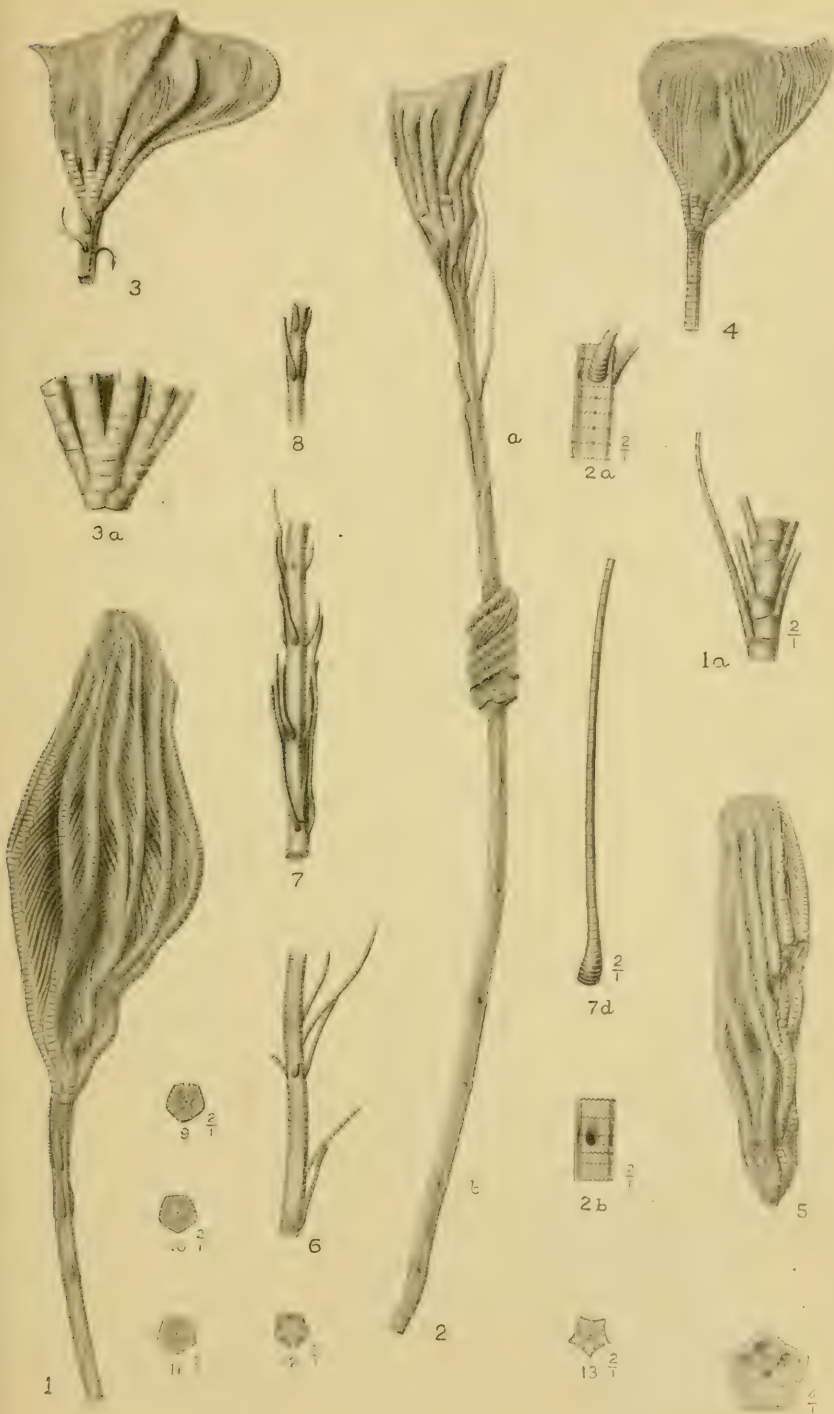
5. Small specimen, *E*; with two arms simple and one bifurcating at 23d IIBr; stem detached, exposing infrabasals.

5a. Basal view of same specimen, showing infrabasals,  $\times 4$ .

6-8. Portions of different stems, *F*, *G*, *H*; showing cirri.

7a. The longest cirrus on specimen *G*,  $\times 2$ .

9-13. Weathered stem joints associated with the other specimens; 9, 10, 11 are mature internodals; 12 is the proximal face of a nodal incised by the cirrus sockets; 13 is a deeply stellate joint from the youngest part of the stem; all,  $\times 2$ .



ISOCRINUS KNIGHTI SPRINGER



DESCRIPTION OF TWO SPECIES OF FOSSIL TURTLES,  
TOXOCHELYS STENOPORA AND CHISTERNON? IN-  
TERPOSITUM, THE LATTER HITHERTO UNKNOWN.

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By OLIVER P. HAY,

*Of Washington, District of Columbia.*

The thanks of the writer are due to the officers of the United States National Museum for the opportunity to describe and illustrate the materials which represent the two species of fossil turtles which form the subject of the present paper.

TOXOCHELYS STENOPORA Hay.

The remains of this species which are here described were obtained from Mr. C. M. Sternberg, of Lawrence, Kansas, in the Niobrara beds along Butte Creek, Logan County, Kansas.

The catalogue number in the U. S. National Museum is 6013. The specimen presents a large part of the bones of a single individual, but in a considerably disturbed condition. Plate 5 shows the position of the various bones after the removal of the matrix that overlay them. Apparently all the bones of the skull are present, but to a considerable extent separated from one another. Very few vertebræ have been preserved. The elements of the carapace have mostly been displaced; those of the plastron to a less extent. The pelvis is missing, as well as most of the bones of the hinder limbs.

The specimen is identified as *Toxochelys stenopora*, but there are not wanting some discordant characters.

The individual was a small one. The carapace had an estimated length of 160 mm. and a width of 167 mm. The width is indicated by some undisturbed right and left peripherals and by the elements of the plastron. The carapace is relatively broader than that of *T. bauri* Wieland.

The front of the skull, including the maxillæ, the vomer, the palatines, and the prefrontals, lay on the slab so as to present the palatal surface (Plate 5, 1). On being removed and cleared from matrix it shows the nasal opening and the anterior half of the orbits. The nasal opening is small, being narrow, as in the type of the species.<sup>a</sup> Its width is 5 mm., its height is 7.5 mm., but this has evidently been

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<sup>a</sup> Hay, Fossil Turtles of North America, p. 172, fig. 217.



reduced by some downward crushing of the prefrontal bones. The orbit seems to have had a fore-and-aft diameter of about 17.5 mm. The width of the interorbital space is 11 mm. A comparison of the snout of this specimen (Plate 5, 1) with that of the type-specimen will show that that of the latter was considerably blunter. This may be due to the greater age of the type-specimen, to sex, or possibly to a difference of species.

On the plate the numeral 8 is placed on what seems to be the outer surface of the left quadratojugal; numeral 9 is on the inner surface of the left jugal. The numeral 10 is on the inner surface of the right jugal, partly covered by a costal plate. The left postorbital, 4, presents its inner surface and lies against the left parietal, but not in the natural relation of the two bones. The numeral 5 is on the outer surface of the right parietal. The inner surface of the right post-frontal, 11, is shown. Attached to its hinder end, apparently in its original place, is the right quadratojugal. The numeral 7 is on the inner surface of the left squamosal. The supraoccipital, 6, has its hinder end directed upward on the plate. It did not have the great height that the same bone of the type had.<sup>a</sup> The left opisthotic, joined to the corresponding prootic, presents its upper surface, 2. Through the wrenching of the supraoccipital from its place, the brain cavity has been exposed, and is seen just above and a little to the right of the numeral 2. The pterygoids are seen in position in front of the brain cavity.

The lower jaw, 3, has been little removed from the position occupied by the skull at the death of the animal. The upper surface of the jaw is exposed to view. The lower jaw greatly resembles that of the type of the species,<sup>b</sup> including the section of the symphysis.

The skull appears to have had a length, from snout to occipital condyle, of nearly 55 mm. One of the ceratohyal bones is seen at the hinder end of the left ramus of the lower jaw.

The structure of the carapace can not be completely determined. Its hinder portion is missing. The nuchal, 18, has the form of that of *T. latiremis*, as figured by Case.<sup>c</sup> It is quite different from that of *T. bauri* Wieland.<sup>d</sup>

On the left side of the carapace there is a series of eight peripherals, 19-26, in their natural relations. It is pretty certain that the anterior one, 19, is the first. The anterior five of the right side are present, 35, 36, 27, 28, 29. The first of the right side and that of the left are separated by a distance equal to the width of the nuchal. The third peripheral on each side, 21 and 27, contains a pit for the end of a rib. Other peripherals, 30, 31, 32, and 34, have been washed forward

<sup>a</sup> Hay, Fossil Turtles of North America, fig. 219.

<sup>b</sup> Idem, fig. 214.

<sup>c</sup> Univ. Geol. Surv. Kansas, IV, pl. 82, fig. 3.

<sup>d</sup> Fossil Turtles of North America, fig. 229.

from their original positions in the skeleton. The pygal is not present.

A few neural bones are present, 12-16. These show that there was a sharp keel running along the middle of the carapace. The number 17 is placed at the side of an ossicle that had a position across the suture between two of the neurals, as in other species of the genus.

Several of the costal plates are present, but some are missing. They have the form usual in the genus, the distal half being very narrow, 37-39, 41-47, 53.

The plastron is present, except the left epiplastron and probably the right xiphiplastron, but the various bones have been slightly disturbed. The front of the plastron was covered with other bones in a way to hide it, and some of these had to be lifted temporarily.

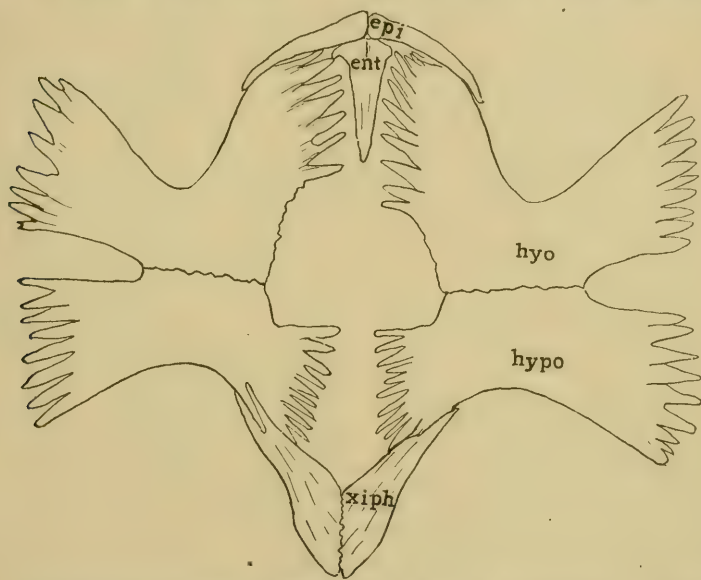


FIG. 1.—TONOCHEILYS STENOPORA. PLASTRON.  $\times \frac{1}{2}$ . *ent*, ENTOPLASTRON; *epi*, EPIPLASTRON; *hyo*, HYOPLASTRON; *hypo*, HYPOPLASTRON; *xiph*, XIPHIPLASTRON.

As accurately as possible, the plastron has been restored in fig. 1. The epiplastra and the entoplastron have not, so far as known to the writer, been hitherto observed. Each epiplastron is a narrow, curved bone 33 mm. long, whose blunt anterior end joins its fellow. These bones were not prolonged forward as they are in *Chelydra* and the *Cheloniidæ*. The entoplastron is a spear-shaped bone, close to 10 mm. wide in front and narrowing posteriorly to a blunt point.

The other bones of the plastron resemble closely those of the type of the species.<sup>a</sup> The bridges have a width of 38 mm., which is equally divided between the hyoplastron and the hypoplastron. The xiphi-

<sup>a</sup> Fossil Turtles of North America, fig. 220.

plastron is 40 mm. long and 11 mm. wide. The hyoplastron and the hypoplastron of the one side seem not to have come into contact with those of the other. There is a large umbilical fontanel.

The scapula, 56, 57 are both present. The right coracoid, 54, is 27 mm. long. The humeri, 55, 58, are each 27 mm. long. The head of that of the right side appears behind a costal, 47, that of the left humerus behind another costal, 39. The left radius and ulna are seen between the scapula, 56, and the humerus, 58. Some fore-foot bones appear in front of the peripherals bearing the numbers 20 and 21. A phalanx, probably of the first digit, extends from the lower jaw, 3, to the right parietal, 5.

CHISTERNON? INTERPOSITUM, new species.

The single known specimen of this species was collected during the summer of 1908 by Mr. C. F. Kay, of the U. S. Geological Survey, in the Livingston coal field of Montana. The formation is the Fort Union. The more exact locality is given as T. 5 S., R. 19 E. This is in Carbon County, about 10 or 15 miles west of north of Red Lodge, and on or near some of the sources of Red Lodge Creek. The catalogue number of this specimen in the U. S. National Museum is 6058.



FIG. 2.—CHISTERNON? INTERPOSITUM. PART OF CARAPACE.  $\times \frac{1}{3}$ . c. p. 1, FIRST COSTAL PLATE; c. p. 3, THIRD COSTAL PLATE; n. n, NEURAL PLATE; n. 1, FIRST NEURAL PLATE; n. 4, FOURTH NEURAL PLATE; per. 1, FIRST PERIPHERAL; pren, PRENEURAL BONE.

The individual is represented by parts of the anterior two-thirds of both the carapace and the plastron. Such parts as can be fitted together are represented by figs. 2 and 3. The other fragments throw little light on the

characters of the species. The sutures between the various bones remained open during life, and may now be followed without difficulty.

The species is referred with some doubt to the genus *Chisternon*, hitherto known only from the Bridger. It possibly belongs to *Boremys* Lambe, known hitherto only from the Belly River beds of Alberta, British America. As in both genera, there is present a preneural bone. In *Boremys* there are supramarginal scutes, in *Chisternon* none. It is possible that in this Fort Union species there were such scutes, but there is little on which to found an opinion. The distal extremity of one costal is present, and this shows no indications of any sulcus crossing it.

The individual was a rather large one, the width having been about 300 mm. The length may have been somewhat greater.



The nuchal bone is broad, about 55 mm., and is more like that of *Boremys* than it is like that of *Chisternon*.<sup>a</sup> The preneural is intermediate in size between that of each of the genera just named, being 18 mm. along the midline, 24 mm. transversely. The first neural is pyriform, 32 mm. long, 26 mm. wide. A part of the posterior end appears as a small separate bone. Each of the three succeeding neurals has a part missing, making its length somewhat doubtful. On the underside of each first costal there is a thickening which joined the axillary buttress. Fragments show that these buttresses were strongly developed.

The first vertebral scute is narrow in front, expanding backward to 60 mm. On each side of it there is a small supernumerary scute. The second vertebral scute is 70 mm. long and 66 mm. wide. Only a part of the third vertebral is represented. In the center of the preneural there is a small flattened ring, as if there had been here a small scute; but the ring is not connected with other sulci. The preneural is not crossed by a sulcus subdividing the first vertebral scute, the latter resembling thus that of *Boremys*.

The plastron furnishes us with knowl-

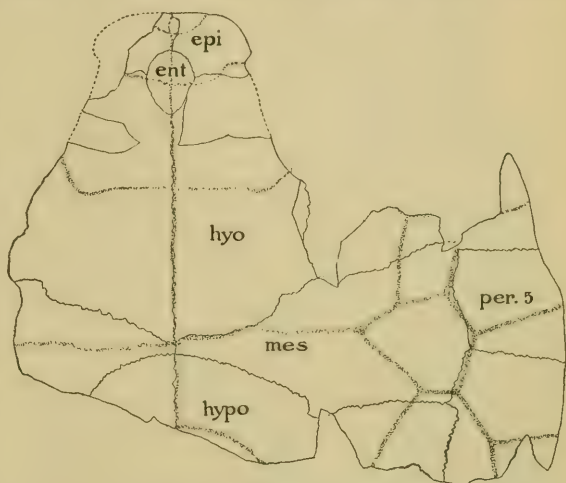


FIG. 3.—CHISTERNON? INTERPOSITUM. PART OF PLASTRON.  
 × 3. ent, ENTOPLASTRON; epi, EPIPLASTRON; hypo, HYOPLASTRON; mes, MESOPLASTRON; per. 5, FIFTH PERIPHERAL.

edge of all essential parts, except the hinder lobe. The length of the anterior lobe is 70 mm., its width about 100 mm. At each end of the gulohumeral sulcus there is a rather deep notch. The entoplastron is 25 mm. long and 19 mm. wide. The mesoplastra are only about 7 mm. wide at the midline, but they expand to 63 mm. where they join the bridge peripherals. There are small intergulars and rather large gulars, the latter joining along the midline 21 mm. The humerals measure along the midline 40 mm.; the pectorals, 63 mm.; the abdominals, 30 mm. These measurements agree more closely with those of *Boremys pulchra* than with those of either of the species of *Chisternon*.

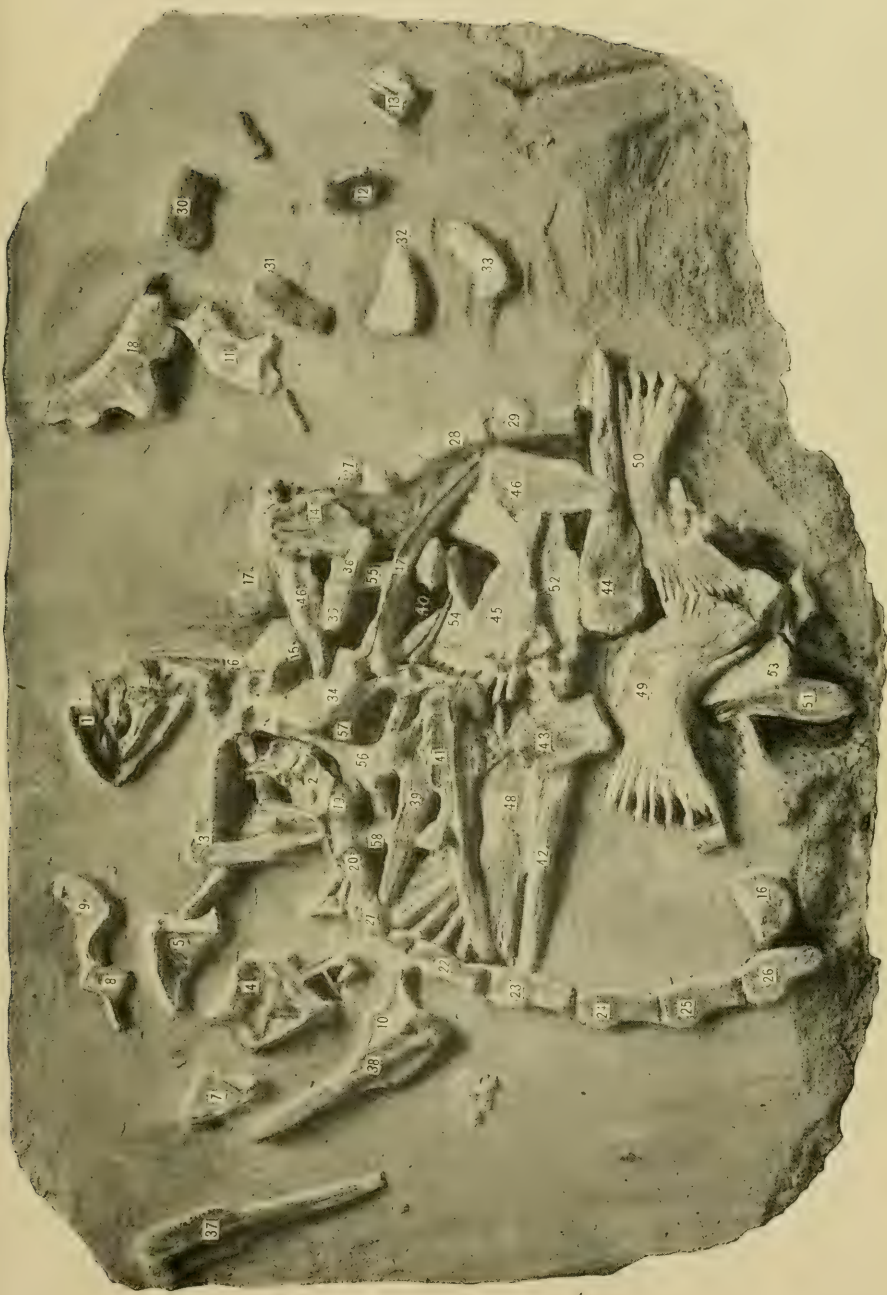
On the left bridge, the only one represented in the specimen, there are shown three inframarginal scutes; but there was evidently another in front of the anterior of the three.

<sup>a</sup> Fossil Turtles of North America, figs. 72, 76, and 88.



## EXPLANATION OF PLATE 5.

1. Palatal surface of the front of the skull.
  2. Left paroccipital. Above and to the left of the numeral is the prootic; above and to the right is the basisphenoid.
  3. Dentary bones, showing the triturating surfaces. The hinder end of the left dentary lies against one of the ceratohyals. The upper end of this ceratohyal lies against the left pterygoid. The right pterygoid touches the hinder end of the right dentary.
  4. Left postfrontal, inner surface. Below it lies the left parietal, showing the outer face. The descending process is directed upward and toward the right.
  5. Right parietal, inner surface. The descending process is directed downward.
  6. Supraoccipital, with the posterior process directed upward.
  7. Left squamosal, inner face.
  8. Left quadratojugal.
  9. Left jugal, inner surface. Orbital surface on the left and looking downward.
  10. Right jugal, inner surface. Orbital surface on the right and looking downward.
  11. Right postfrontal, inner surface, hinder end upward. Above it and apparently in natural relation to it is the right quadratojugal.
  12. A neural bone, with the median ridge toward the left.
  13. Part of a neural.
  14. A large neural, showing its inferior face.
  15. A short neural, the numeral on the median ridge.
  16. A neural.
  17. An ossicle that occupied a position across the suture between two neurals.
  18. The nuchal bone, upper surface.
  - 19-26. Peripheral bones, first to eighth of the left side.
  - 27-29. Peripheral bones, third to fifth of right side.
  - 30-34. Firstals, all probably of right side.
  - 35, 36. First and second peripherals of right side.
  - 37-39. Costal bones.
  40. Right epiplastron.
  - 41-47. Costal bones.
  48. Left hyoplastron.
  49. Left hypoplastron.
  50. Right hypoplastron.
  51. Left xiphiplastron.
  52. Right hyoplastron.
  53. A short costal bone.
  54. Right coracoid, its left end lying on the right hyoplastron.
  55. Right humerus, its proximal end showing behind the numeral 47.
  56. Left scapula, the shaft directed upward, the procoracoid process to the right.
  57. Right scapula, the shaft passing under that of the left scapula, the procoracoid process directed backward.
  58. Left humerus, the proximal end passing backward under costal numbered 39.
- Above the numeral 54 there is seen a slender bone whose head is toward the left. This seems to be one of the reduced first ribs. The head of this bone lies against the entoplastron. The anterior end of the latter bone is overlain by the extremity of the procoracoid process of the right scapula, 57,



SKELETON OF *TOXOCHELYS STENOPORA*. PL. 5.

FOR EXPLANATION OF PLATE SEE PAGE 196.



# OSTEOLOGY OF THE JURASSIC REPTILE CAMPTOSAURUS, WITH A REVISION OF THE SPECIES OF THE GENUS, AND DESCRIPTIONS OF TWO NEW SPECIES.

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By CHARLES W. GILMORE,

*Custodian of Fossil Reptiles, U. S. National Museum.*

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## INTRODUCTION.

Twenty-nine years have passed since Prof. O. C. Marsh and his assistants made the first discovery of camptosaurian remains in the Jurassic deposits of North America. During this period, with the exception of a number of short papers prepared at various intervals by Professor Marsh, little has been written concerning this interesting group of extinct reptiles. Their apparent neglect is no doubt due in large part to the dearth of material, for, despite the fact that the gathering of collections has been continued with increased activity during the past eleven years by representatives of the various scientific institutions of the United States, but little new camptosaurian material has been brought to light.

The fossils upon which the present paper is largely based were acquired by the U. S. National Museum through the U. S. Geological Survey, being contained in that part of the Marsh collection transferred to the Museum in 1900. The greater part of the material was in the same condition as when received from the field many years previous, and its preparation in so complete a condition, in view of its rarity, has been most gratifying. Not only are there many individuals represented, but the perfection of two of the skeletons throws much additional light on their structural characteristics, and it has been thought advisable to give here for the first time a detailed description of the osteological structure of the genus. This will be followed by a discussion of the species in anticipation of defining their more important characteristics. This work was made possible by the study of the types and other specimens contained in the collections of the Yale University Museum, which were generously placed at my disposal.



The most serious difficulty in the proper study of the type-specimens was due to their lack of preparation. It is hoped, however, that in the text and figures presented here a little has been added to our conception of a form long neglected.

I take this opportunity to express my appreciation of the assistance given me during the preparation of this paper. To Dr. George P. Merrill, head curator of the department of geology, U. S. National Museum, I am first of all indebted for making possible the arrangements for the preparation and study of this material, and I gratefully acknowledge the many privileges extended; to Prof. Charles Schuchert, of the Yale University Museum, I am under obligations for the generous manner in which he placed at my disposal the types and all other camptosaurian material contained in the collections under his charge. I also wish to thank Prof. R. S. Lull, of the same institution, for courtesies extended during my visit to New Haven. For the privilege of studying material and assistance rendered, I am grateful to Dr. W. D. Matthew and Mr. Barnum Brown, of the American Museum of Natural History, New York. I am also indebted to Mr. Norman Boss, of the U. S. National Museum, for efficient assistance in the preparation of material, and to Miss M. W. Moodey in the final preparation of the manuscript.

#### HISTORY OF THE DISCOVERY OF QUARRY NO. 13.

With the specimens upon which the present paper is based were found many of the original field labels, on which the locality is given as "Quarry No. 13 or No. 13½, 8 miles east of Como, Wyoming." A brief history of the discovery and methods employed in working this important deposit of fossil remains is here given on account of the perfection of many of the specimens found in the quarry. It has furnished the holotypes of *Camptosaurus dispar*, *C. nanus*, and the allied forms, *Dryosaurus altus*, besides a vast quantity of other material, chiefly pertaining to the Stegosauridae, among which are the holotypes of *Stegosaurus sulcatus* and *Diracodon laticeps*.<sup>a</sup> In response to an inquiry made of Mr. W. H. Reed, of Laramie, Wyoming (the original discoverer), as to the history of the discovery of this deposit of fossils, he writes:

In August, 1879, I could see the end of quarry No. 10, where the type of *Brontosaurus excelsus* Marsh was found, so I took one of my men, Mr. E. G. Ashley, and we started out east from the main bluff (or Como-bluff). On the fourth day of our search, in the afternoon, being in the lowest of the Jura bone horizon, we found some hollow bones in the wash and soon after discovered the quarry. The first bones to be taken up was a nearly complete skeleton of *Allosaurus*. After this skeleton had been taken out, we found large quan-

<sup>a</sup> Prof. R. S. Lull informs me that the holotypes of *Cœlurus fragilis* and *Morosaurus lentus* also came from this quarry.

titles of *Stegosaurus* and *Camptosaurus* bones. This quarry was entirely different from any other Jurassic quarry I have ever seen, the matrix being a fine quality of sand. \* \* \* There were also numerous small tubes with an outer crust of calcite. These were nearly uniform in size and about one-half inch in diameter. There were no large dinosaur bones found in this quarry, but it seemed to be a favorite resort for the smaller species. \* \* \* The quarry was cut through by two gulches, and that portion on the west side of the west gulch was called 13 west, that part between the gulches was 13 east, and that on the east side of the east gulch was 13½. This is as I started the work, and I believe Brown continued this plan. \* \* \* I find in my old notebooks the original locations that were filed in 1879 in order to hold it from trespassers.

An inclosure in the above letter shows the quarry to have been located in the northeast quarter of section 5, township 22 north, of range 76 west, Albany County, Wyoming.

Under the supervision of Mr. Reed, at that time employed by Prof. O. C. Marsh, quarry No. 13 was worked for the remainder of the season of 1879 and during the summers of 1880, 1881, and 1882. In 1883 further excavations were made under the direction of Mr. J. L. Kenney, and in 1884, Mr. Fred Brown assumed charge of the explorations, which were continued uninterruptedly until the autumn of 1887, when the quarry was abandoned as exhausted.

#### PLAN OF WORK.

The fossils collected from quarry No. 13 prior to 1882 are now preserved in the collection of the Yale University Museum, while the specimens resulting from the later excavations (the expense of collecting having been defrayed by the U. S. Geological Survey) are now in the paleontological collections of the U. S. National Museum. Much of this material still remains in the original packages as collected from twenty-one to twenty-six years ago.

Rough sketch maps of the quarry were made by Reed, on which he indicated the relative positions of all of the important bones found. Unfortunately only a few of these are now available. Later Brown formulated a more detailed plan of recording the relative positions of the specimens uncovered. The quarry was divided (see fig. 1) into what he designated diagrams, beginning with No. 1 and ending with No. 13. In some cases it is found that one diagram represented a season's work, while in other instances several diagrams were worked out in one year, probably due to the varying number of fossils found in the different sections. The diagrams were subdivided into 2-foot squares and, the maps being platted on the scale of 2 feet to the inch, bones as found could be accurately located on them. Each bone or group of bones (when taken up in one block) was given a quarry number, the bones found in each diagram beginning with number 1 and continuing serially for all of the specimens in that section.

The number being placed on a label with the specimens, as well as on the map, the exact position of a bone in relation to those found

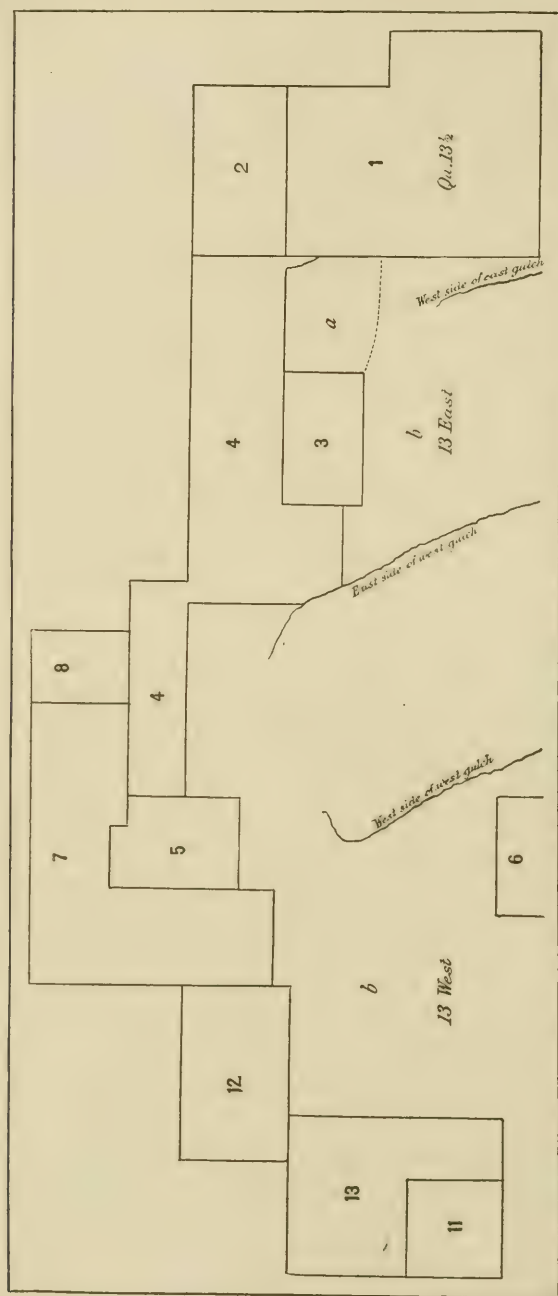


FIG. 1.—MAP OF QUARRY 13, SHOWING THE RELATIVE POSITIONS OF THE DIAGRAMS AS WORKED BY MESSRS. REED, KENNEY, AND BROWN FOR PROFESSOR MARSH, FROM 1879 TO 1887, INCLUSIVE. SCALE ABOUT 30 FEET TO THE INCH. 1, 2, 3, AND 4, DIAGRAMS ONE TO FOUR WORKED BY BROWN IN 1884; 5, DIAGRAM FIVE, WORKED BY BROWN IN 1885; 6, DIAGRAM SIX, WORKED BY BROWN; 7, 8, 11, AND 12, DIAGRAMS SEVEN, EIGHT, ELEVEN, AND TWELVE, WORKED BY BROWN IN 1886; 13, DIAGRAM THIRTEEN, WORKED BY BROWN IN 1887; *a*, GROUND WORKED BY KENNEY IN 1883; *b*, GROUND WORKED BY REED IN 1879, 1880, 1881, AND 1882; *Qu. 13 1/2*, IS ONLY RELATIVELY LOCATED, BEING ON THE EAST SIDE OF EAST GULCH. COMPILED FROM DIAGRAMS MADE BY MR. FRED BROWN.

near it could be quickly and accurately determined in the laboratory. Unfortunately a compilation of the several diagrams had never been

made, and it was only after a most tedious search that the relative positions of those shown in fig. 1 were determined. There was no data found whereby diagrams 9 and 10 could be accurately located, and the area worked by Reed can only be indicated in a general way.

POSITION OF THE BONES OF CAMPTOSAURUS BROWNI AS FOUND IN THE QUARRY.

The most complete specimen considered in this paper is a new species, *Camptosaurus browni* (Cat. No. 4282, U.S.N.M.), which was collected by Mr. Fred Brown from quarry No. 13, 8 miles east of Como, Albany County, Wyoming, in 1885 and 1886. The accompanying map (see Plate 6) shows plainly how the bones of this individual were found as they lay embedded in the ground. The diagrams were drawn (as explained previously) at the time of disinterment, and the painstaking care bestowed on them is worthy of the highest commendation. Nearly a quarter of a century has elapsed since this skeleton was collected. During the interval the material from this area had become widely scattered, but by the aid of the diagrams the specimens were not only assembled, but I was enabled to again place all of the elements in their original relative positions.

Most of the skeleton lay in diagram 5, but a study of the contiguous area represented by diagram 7 showed other elements which could, beyond a reasonable doubt, be associated with the same individual, although collected a year later. The main axis of the skeleton lay in a northeast and southwest direction, and apparently not far removed from where the animal died.

As indicated by the original quarry numbers, the left fore limb and foot and anterior dorsal vertebræ were the first elements discovered. The limb and foot bones lay on the left side of the vertebral column in the positions indicated on the map (see Nos. 83, 84, and 85), the scapula and coracoid being removed some 5 feet to the left of the lower limb bones, but inasmuch as this is the only skeleton of *Camptosaurus* found in this part of the quarry, and as it pertains to the left side, there can be no doubt of their proper association. The vertebral column, which appears quite complete, was disarticulated at intervals. Beginning with the anterior portion of the backbone as preserved, cervicals 78, 77, and 76 were articulated by their zygapophyses and represent, respectively, the eighth and ninth cervicals and first dorsal. No. 83, although not interlocked with 78, was but little removed from it, and appears without question to represent the seventh cervical. Two other cervicals, No. 109 and another from which the original quarry number had been erased, are also provisionally associated with this skeleton, and represent the fourth and third cervicals, respectively. On account of the erasure of the quarry



number the position of the third cervical could not be found on the map, although it was associated with the bones of No. 4282. The vertebræ of the next series, Nos. 101 to 106, while not interlocked by their zygapophyses, were so closely associated that there can be no question of their representing a series, and when prepared fit one another perfectly. The position of the capitular facets and shape of the spinous processes show them to pertain to the anterior dorsal region. An interval of a foot or more existed between No. 106 of this series and No. 76. In the next series, Nos. 120 to 136, the vertebræ were found occupying their relative positions and but little disturbed. From the adhering matrix I was able to connect up this series from the mid-dorsal through the sacral into the anterior caudal region, and an unbroken series is undoubtedly represented from the eighth dorsal back through the sacrals to the fourth caudal, inclusive. Caudals Nos. 168 to 169 and Nos. 158 and 159 were removed somewhat laterally, but were intermediate in size and appear to fill the gap between 136 and 170. Nos. 170 to 174, with their chevrons, were found articulated. Another series of four vertebræ (block 208) was shown in diagram 7, some 14 feet to the east of No. 174. But an anterior zygapophysis, retained in place by the matrix of the latter, was found to fit on the first vertebra of this series, and so fixed beyond doubt their proper position in the tail. Some 14 or 15 feet to the north and east another series of eighteen distal caudals (Nos. 218 to 235) was found, most of them articulated or so closely associated that it appears none are missing in the series.

It is perhaps fortunate that while the other bones found in this area represent the remains of several individuals, nearly all pertain to the genus *Stegosaurus*, from which the elements of *Camptosaurus* are readily distinguishable. This remark applies particularly to the rounded distal caudals of *Camptosaurus* which may at once be distinguished from the short hexagonal caudal centra of *Stegosaurus*. That this distal series belongs to *C. browni* there can be but little question. The ilia, Nos. 140 and 167, lay on their respective sides of the sacrum and but little removed from it, with their anterior ends directed forward. The other pelvic bones were not indicated on the map, but from their quarry numbers it was determined they could not have been far removed. Nothing of the hind limbs was found. The right fore limb (and foot) Nos. 98, 101, 119, and 120, were found to the west and right of the anterior cervicals. From the fact that all of the elements pertain to a right limb and closely agree in size with the left, its assignment appears certain. Some scattered ribs and pieces found near the dorsals have been provisionally associated with them. All of the remaining material from diagrams 5 and 7 has been gone over carefully in the hope of finding some elements of the skull and other missing parts, but with-

out reward. It appears remarkable that in a skeleton which shows so little displacement of the elements as this one, that the heavy bones of the hind limbs should be missing. An unusual feature is the preservation of both fore limbs and feet. Experience of several seasons' field work has shown that while it is not unusual to find hind limbs fairly complete, the front legs, particularly of the Jurassic sauropods, are rare.

By reference to the quarry map (see Plate 6), all of the evidence as to the association of the parts may be plainly seen. The bones not numbered pertain to one or more genera different from *Camptosaurus*. The series to the east of the vertebral column represents a caudal series of *Stegosaurus*, and most of the other scattered elements have been recognized as belonging to that genus. With the exception of two caudal vertebrae, no duplicate bones of *Camptosaurus* have been found. There can be therefore little question but that all of the elements indicated as *Camptosaurus* belong to the one individual.

The position of the bones of the skeleton, as found in the quarry, is shown in diagrams 5 and 7, Plate 6. The position of the different parts is indicated by the original quarry numbers as follows:

## IN DIAGRAM 5.

81. Dorsal rib.	129 to 133. Sacrals.
83. Dorsal rib.	134 to 136. Caudals (1, 2, and 3 of series).
84. Left humerus.	
85. Left radius, ulna, and manus.	140. Left ilium.
98. Spinous process.	157. Portion of dorsal rib.
101 to 106. Dorsals (2, 3, 4, 5, 6, and 7 of series).	158. Caudal (6th of series).
106. Thoracic rib.	159. Caudal (5th of series).
107. Head of dorsal rib.	167. Right ilium.
109. Piece of dorsal rib.	168. Caudal (3rd of series).
113. Portion of right ischium.	169. Caudal (4th of series).
115. Left ischium.	170 to 174. Caudals (7, 8, 9, 10, 11, and 12 of series).
116. Dorsal rib (portion of head).	175, 176. Caudal vertebrae.
120 to 128. Dorsals (8th to 16th of series).	178. Chevron.

## IN DIAGRAM 7.

45. Left scapula.	109. Fourth cervical.
46. Left coracoid.	119. Right radius and ulna.
76. First dorsal.	120. Right manus.
77. Ninth cervical with one rib.	177. Ungual of Digit IV, right hind foot.
78. Eighth cervical with both ribs.	
83. Seventh cervical.	208. Caudals (13, 14, 15, and 16 of series).
84. Right humerus.	
98. Right coracoid.	218 to 235. Caudals (21st to 38th of series).
101. Right scapula.	

## OSTEOLOGY OF CAMPTOSAURUS.

In the following pages an attempt is made to give a detailed description of the complete osteology of *Camptosaurus*, which, to a great extent, is based upon material preserved in the paleontological collections of the U. S. National Museum. This is supplemented, however, in many instances, and corroborated in others, by a study of the types and other specimens in the Yale University Museum, the collections of these two institutions containing the greater portion of the known *Camptosaurus* material from the Jurassic of this country.

Primarily the detailed description of the skeleton is based on Cat. No. 4282, U.S.N.M., holotype<sup>a</sup> of the new species, *C. browni*. I have selected this specimen on account of its representing a considerable portion of one individual, concerning the association of whose parts there can be but little question raised. Reference will occasionally be made to other individuals, where important structural differences are displayed, and bones not represented in this skeleton will be described from other specimens.

## THE SKULL.

A complete articulated skull of *Camptosaurus* is unknown, although nearly all of its component parts have been recognized from the several disarticulated and fragmentary crania now preserved in the collections of the National and Yale museums.

Marsh was the first to attempt a restoration of the skull, which was based primarily upon the disarticulated elements of No. 1880 (holotype of *C. medius*), and the well-preserved anterior and posterior portions of No. 1887, Yale Museum, shown in Plates 7, 8, and 9 of the present paper. The latter specimen represents a very much larger individual, and, as suggested elsewhere, probably pertains to a distinct species. Thus the skull as figured could hardly be distinctive of *C. medius*, as formerly considered.

The restoration presented here (see figs. 2 and 3) is based upon the one given by Marsh, with such corrections and emendations as better preserved and more abundant material renders possible, and while it is anticipated that future discoveries will undoubtedly show the present restoration to be in error in some particulars, still it is believed that a clearer and more correct conception of the skull of *Camptosaurus* is given than could be obtained from the earlier representations.

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<sup>a</sup>This is a term defined by Schuchert (Bull. U. S. Nat. Mus., No. 53, Pt. 1, 1905, p. 10): "A holotype in natural history is a particular individual deliberately selected by the author of a species, or it may be the only example of a species known at the time of original publication. A holotype, therefore, is always a single individual, but may embrace one or more parts, as the skin, skeleton, or other portions, such as the obverse and reverse of a natural mould."



The occipital region, parietals, and frontals have been largely based upon the posterior portion of a skull of *C. dispar*, No. 5473, U.S.N.M.

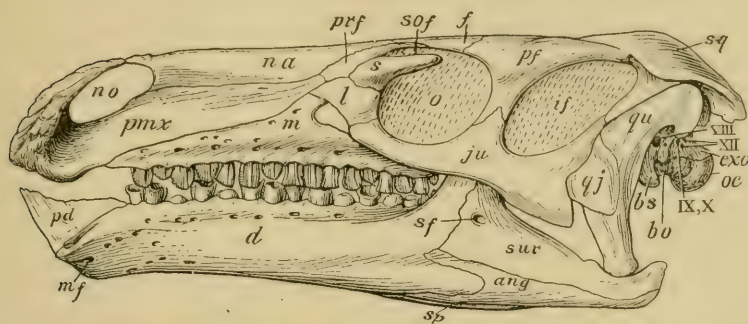


FIG. 2.—SKULL OF CAMPTOSAURUS. COMPOSITE RESTORATION; ABOUT  $\frac{1}{2}$  NAT. SIZE. SEEN FROM THE LEFT SIDE; *ang*, ANGULAR; *bo*, BASIOCCIPITAL; *bs*, BASIPHENOID; *d*, DENTARY; *exo*, EXOCCIPITAL; *f*, FRONTAL; *if*, INFRATEMPORAL FOSSA; *ju*, JUGAL; *l*, LACHRYMAL; *m*, MAXILLARY; *mf*, MENTAL FORAMEN; *na*, NASAL; *no*, NASAL ORIFICE; *o*, ORBIT; *oc*, OCCIPITAL CONDYLE; *pd*, PREDENTARY; *pf*, POSTFRONTAL; *pmx*, PREMAXILLARY; *prf*, PREFRONTAL; *qj*, QUADRATOJUGAL; *qu*, QUADRATE; *s*, SUPRAORBITAL; *sf*, EXTERNAL MANDIBULAR FORAMEN; *sof*, SUPRAORBITAL FOSSA; *sp*, SPLENIAL; *sq*, SQUAMOSAL; *sur*, SURANGULAR; *VIII*, INTERNAL AUDITORY MEATUS; *IX, X*, FORAMEN LACERUM POSTERIUS; *XII*, HYPOGLOSSAL FORAMEN, AND FORAMEN FOR EXIT OF VEIN.

(see Plates 10 and 11). The anterior half as well as the infero-posterior part are after No. 1887, Yale Museum (see Plates 7 and 8).

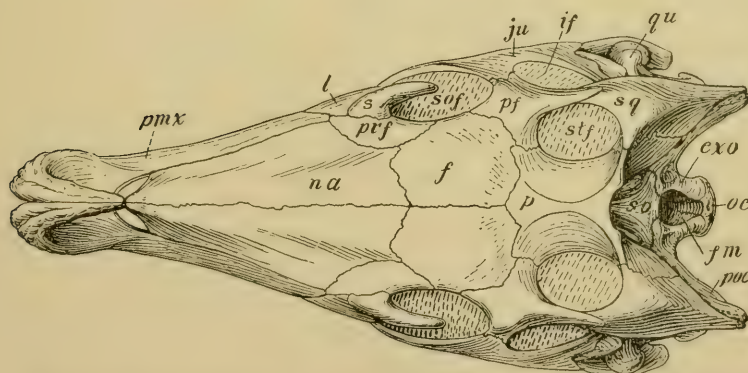


FIG. 3.—SKULL OF CAMPTOSAURUS. COMPOSITE RESTORATION; ABOUT  $\frac{1}{2}$  NAT. SIZE. SEEN FROM THE TOP; *exo*, EXOCCIPITAL; *f*, FRONTAL; *fm*, FORAMEN MAGNUM; *if*, INFRATEMPORAL FOSSA; *ju*, JUGAL; *l*, LACHRYMAL; *na*, NASAL; *oc*, OCCIPITAL CONDYLE; *p*, PARIETAL; *pf*, POSTFRONTAL; *pmx*, PREMAXILLARY; *poc*, PARAOCIPITAL PROCESS OR OPISTHOTIC; *prf*, PREFRONTAL; *qu*, QUADRATE; *s*, SUPRAORBITAL; *so*, SUPRAOCCIPITAL; *sof*, SUPRAORBITAL FOSSA; *sq*, SQUAMOSAL; *stf*, SUPRATEMPORAL FOSSA.

The lower jaw and maxillary are partly after No. 1887 and partly after No. 1886 (see figs. 7 and 8), also in the Yale Museum. No. 1880,



although largely disarticulated, furnished much additional as well as corroborative information. A study of the disarticulated elements of several other individuals assisted greatly in the proper interpretation of their arrangement.

The predentary of *Camptosaurus* is as yet unknown, but as represented here is a modification of the *Iguanodon* type rather than of *Triceratops*, as first represented.

A restudy of the material now available has resulted in a number of modifications and changes, the more important of which may be briefly enumerated as follows:

(1) A more detailed presentation of the arrangement of the elements of the occipital and parietal segments.

(2) The removal posteriorly of the coronoid process of the mandible, which alters considerably the proportionate values of the dentary and the posterior elements of the jaw, that is, the lengthening of the former and shortening of the latter.

The many minor changes will be alluded to in more detail in the description of the elements to follow.

Viewed from above the skull is wedge-shaped, with the apex directed forward. When seen laterally it is of moderate depth, wider posteriorly than anteriorly, with a prominent orbit and large infratemporal fossa. The rami are moderately deep, but not so wide and heavy as in *Iguanodon*.

*Basioccipital*.—The heavy basioccipital is terminated posteriorly by the rounded occipital condyle, which is somewhat reniform in outline. In Cat. No. 5473, U.S.N.M., its greatest horizontal diameter is 40 mm. and its vertical diameter 25 mm. The smooth articular surface is continued forward on the under side of the condyle as a triangular area, the apex pointing anteriorly. The continuation of this articular surface would appear to indicate a greater mobility of the head up and down than from side to side, at the joint with the atlas. This would allow the anterior portion of the cranium to be considerably depressed.

In advance of the condyle the inferior surface is deeply concave longitudinally and convex transversely, with quite a pronounced median depression. Anteriorly and on either side of this depression are two blunt, roughened, basioccipital processes which abut against the expanded processes of the basisphenoid, the free extremities of which point downward and backward, and underlap those of the basioccipital. The basioccipital articulates with the basisphenoid by a median, tongue-like anterior extension, which is received in a corresponding notch on the posterior end of the latter, as in *C. prestwichii*. The intercalated basioccipital process on the ventral surface has a sharp median crest which begins behind in a depression in front of the condyle. The median superior surface is concave

transversely and forms the floor of the foramen magnum. On either side of this depression are rough sutural surfaces for the exoccipitals, the posterior terminations of which enter slightly into the formation of the ball of the occipital condyle at its upper lateral corners.

*Exoccipital and opisthotic or paraoccipital.*—The exoccipitals form the greater part of the boundary of the foramen magnum and contribute slightly to the formation of the occipital condyle. Seen from behind, they rise as pillars from the condyle, articulating dorsally by oblique sutures with the supra-occipital, and continuing latero-posteriorly into the broad opisthotics or paraoccipitals. On the median posterior surface, just external to the lateral border of the foramen magnum, are pronounced circular depressions (see fig. 4). Dorsally, the paraoccipital appears to support the parieto-squamosal processes much as in *Stegosaurus*. The exoccipital and opisthotic are firmly coalesced, and there is no indication of the position of the suture, which evidently was early obliterated. On the inferior lateral surface of the exoccipital are four small foramina, one in front of another, the anterior one being separated from the other three by an oblique ridge. The more posterior pierces the exoccipital and enters the foramen magnum just within the external opening of the latter. As in

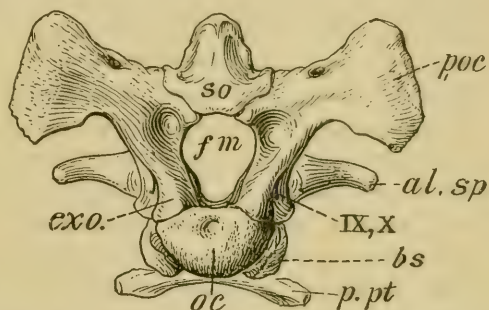


FIG. 4.—POSTERIOR VIEW OF OCCIPITAL REGION OF SKULL OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5473, U.S.N.M.;  $\frac{2}{3}$  NAT. SIZE. *Al. sp.*, ALISPHE-NOID; *bs*, BASISPHENOID; *exo.*, EXOCCIPITAL; *fm*, FORAMEN MAGNUM; *oc*, OCCIPITAL CONDYLE; *poc*, PARAOC- CIPITAL PROCESS OR OPISTHOTIC; *p. pt.*, PROCESS ON BASISPHENOID WHICH MEETS THE PTERYGOID; *so*, SUPRAOC- CIPITAL; IX, X, FORAMEN LACERUM POSTERIUS.

*Morosaurus agilis*, *Diplodocus*, *Stegosaurus*, and *Triceratops*, this doubtless served to transmit the hypoglossal, or twelfth nerve; the next anterior which enters the foramen more inferiorly, instead of a branch of the twelfth nerve, as indicated in the figures, may have transmitted a vein, as in the crocodile; the third, which is separated from those posteriorly by a slight vertical ridge, was probably the exit for the pneumogastric and glossopharyngeal nerves, while the fourth, the function of which is undetermined, passes diagonally through the outer anterior edge of the exoccipital and enters the large foramen just within its external opening. The nearly vertical suture between the opisthotic and prootic is plainly indicated on the portion of the skull of Cat. No. 5473, U.S.N.M. (see fig. 5). The broad paraoccipital processes extend outward and backward beyond the posterior termination of the condyle (see Plate 10, fig. 2). Viewed posteriorly (see fig. 4), the median part is con-

stricted, while the outer termination is expanded both dorsally and ventrally, more especially in the latter direction, into a wide, somewhat broadly rounded end. The posterior surface of this process is gently convex dorso-ventrally, while the anterior surface is plane, with a shallow, longitudinal groove extending for part of its length on the anterior inferior border.

*Supraoccipital*.—The supraoccipital of *Camptosaurus*, as in the English *Hypsilophodon* and *Camptosaurus prestwichii*, enters into the formation of the boundary of the foramen magnum. It contributes to the upper median boundary, and extends forward and upward into a stout pyramidal median crest, which is inclosed dorsally and laterally by the parietals. Ventrally it articulates by heavy sutured surfaces with the obliquely placed dorsal faces of the exoccipitals and prootics. The principal characters of this bone and the relation it bears to the surrounding elements of the skull are clearly shown in figs. 4 and 5.

*Basisphenoid and parasphenoid*.—The basisphenoid is very heavy and broad posteriorly where it articulates with the basioccipital by a deep vertical suture. On its posterior ventral surface two heavy, roughened buttresses are developed, which slightly underlap the anterior end of the basioccipital, and between which is received a heavy, median, tongue-like prolongation of the basioccipital. Anteriorly it is narrower and gives off a pair of diverging processes or pillars, produced somewhat below the ventral surface. These are directed downward, backward, and outward, and present in front at their extremities, surfaces for contact with the pterygoids (see *p*, *pt*, fig. 5). Latero-ventrally the basisphenoid is compressed, having laterally, one on either side, two forwardly directed slits, from which two converging foramina extend forward into the pituitary fossa. These foramina probably transmitted the carotid arteries, as in the crocodile (see *c*, fig. 5). They are also present in *Triceratops*, *Stegosaurus*, and *Iguanodon*. Dorso-laterally the basisphenoid articulates with the exoccipital, prootic, and alisphenoid. The parasphenoid extends forward from the base of the pituitary fossa as a median prolongation of the basisphenoid and divides the interpterygoid vacuity posteriorly into two parts. Its anterior extent, however, can not be determined from available material.

*Alisphenoids*.—The alisphenoids are a pair of roughly triangular bones which arise from the anterior dorsal surface of the basisphenoid, and unite dorsally as in the crocodile with the parietal, frontals, and postfrontals (see fig. 5). Their inner surfaces form the walls of that part of the brain case which lodges the cerebral hemisphere. Their anterior ends are divergent, turning decidedly outward, their dorsal surfaces being received in a transverse groove on the anterior ventral surface of the postfrontal. A narrow, pos-



teriorly notched process descends to the basisphenoid and with it by a slightly expanded end. The posterior border of the process forms the anterior margin of the foramen ovale for the transmission of the trigeminal or fifth nerve (see V, fig. 5.) Above the foramen ovale the alisphenoid is united by suture to the prootic bone, as plainly shown in Cat. Nos. 5473 and 5997, U.S.N.M. Their external surfaces form part of the inner and anterior boundaries of the supratemporal fossa. The alisphenoids in *Stegosaurus* appear to be identical in shape, position, and relationship, as regards the surrounding elements.

*Orbitosphenoids.*—Ossified orbitosphenoids were undoubtedly present, as indicated by two thin, flattened, plate-like elements found in the matrix with the alisphenoids of Cat. No. 5997, U.S.N.M. Furthermore, these appear (if not mutilated) to be large enough to complete the anterior portion of the brain case, as shown by specimen Cat. No. 5473, U.S.N.M. If present, they would form the walls which enclose the olfactory lobes of the brain.

*The prootic.*—Between the occipital and parietal segments of the skull of *Camptosaurus* is an area which must represent the position of the auditory or periotic capsule. As in most reptiles, the elements forming the capsules, i. e., the opisthotic and epiotic, are probably fused so that their exact identification is rendered somewhat difficult, the prootic alone remaining differentiated in the adult.

The prootic, as plainly shown by the two specimens, Cat. Nos. 5473 and 5997, U.S.N.M., is bounded as follows: Posteriorly by the opisthotic; dorsally by the supraoccipital, unless the epiotic be fused with that bone, a point, however, which can not now be determined; anteriorly by the alisphenoid, and ventrally by the basisphenoid. These relations are clearly shown in the specimens studied, as the sutures remain distinct in both.

In Cat. No. 5997, U.S.N.M., the prootic is all that remains of the lateral walls of the brain case, still attached to the basisphenoid, the alisphenoids, and orbito-sphenoids being present but detached from the rest of the specimen. As shown by a third specimen, No. 5996, U.S.N.M., these elements are united to the basisphenoid antero-posteriorly by pit-like, roughly sutured surfaces, but above they expand into a thickened wing-like dorsal portion produced more especially in the posterior direction, which extends backward and outward and laps along the median anterior surface of the outward extension of the opisthotic, uniting by horizontally striated sutural surfaces. Above the large foramen (internal auditory meatus, see VIII, fig. 5), the suture between the prootic and opisthotic is nearly vertical up to the backward projection of the former. The dorsal surface is united by an inclined sutural surface (see s, fig. 5) with the overlying supraoccipital. The figure shows the supraoccipital crushed upward from



position and thus exposes the ventral sutural surface in juxtaposition, would unite closely with the transversely sutured dorsal surface of the prootic. Anteriorly it presents a thickened sutural surface for union with the alisphenoid. Below, the anterior border is deeply notched by the foramen ovale. The upper exterior surface forms part of the lower inner boundary of the supratemporal fossa. On the lower median part of the lateral surface is a deep, vertical groove leading up to a foramen entering the brain case, which, from its position, should represent the exit of

the seventh or facial nerve. (See VII, fig. 5.)

In the skull of *Triceratops*, Hatcher<sup>a</sup> was unable to distinguish the prootic, and in *Diplodocus*, Holland<sup>b</sup> did not detect its presence. In both cases the region which it should occupy if present was considered a part of the alisphenoid. From the facts brought out by a study of the skull of *Camptosaurus* which shows the presence of the otic elements in the dinosaurian skull, I believe they will be found in both of the forms mentioned above. In this connection it is of interest to quote from Huxley<sup>c</sup> who says: "The prootic is, in

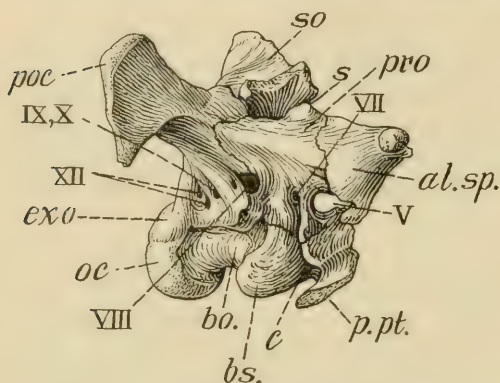


FIG. 5.—LATERAL VIEW OF POSTERIOR PORTION OF SKULL OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5473, U.S.N.M.;  $\frac{2}{3}$  NAT. SIZE. *Al. sp.*, ALISPHE-  
NOID; *bo.*, BASIOCCIPITAL; *bs.*, BASISPHENOID; *c*,  
GROOVE LEADING TO FORAMEN THROUGH WHICH THE  
CAROTID ENTERS PITUITARY FOSSA; *exo*, EXOCCIPIT-  
AL; *oc*, OCCIPITAL CONDYLE; *poc*, PARAOC-  
CIPITAL PROCESS OF OPISTHOTIC; *p. pt.*, PROCESS FOR PTERY-  
GOID; *pro*, PROOTIC; *s*, SUTURAL SURFACE OF  
SUPRAOC-  
CIPITAL, CRUSHED UPWARD FROM ITS NOR-  
MAL POSITION IN RELATION TO THE PROOTIC WITH  
WHICH IT UNITES; *so*, SUPRAOC-  
CIPITAL; *V*, FORAMEN  
OVALE; *VII*, FORAMEN FOR SEVENTH OR FACIAL  
NERVE; *VII*, INTERNAL AUDITORY MEATUS; *IX, X*,  
FORAMEN LACERUM POSTERIUS; *XII*, HYPOGLOSSAL  
FORAMEN, AND FORAMEN FOR EXIT OF VEIN.

fact, one of the most constant bones of the skull in the lower vertebrates, though it is commonly mistaken, on the one hand for the alisphenoid, and on the other for the entire petro-mastoid."

The epiotic I am unable to recognize and if present, it occurs, as in most reptiles, fused with the supraoccipital, and no longer recognizable.

*Parietal.*—As in most reptiles (excepting *Chelonia*, *Ichthyosauria*, and some *Theromorpha*), the parietals in *Camptosaurus* are united. (See Plate 10.) An examination of two disarticulated skulls in which

<sup>a</sup> Mon. U. S. Geol. Survey, XLIX, 1907, p. 17.

<sup>b</sup> Memoirs Carnegie Museum, II, No. 6, 1906, p. 236, fig. 8.

<sup>c</sup> The Anatomy of Vertebrated Animals, 1872, p. 26.

all other sutures are distinctly seen, failed to show any indication of an interparietal suture. Hulke<sup>a</sup> has observed that *Hypsilophodon foxii*, *Iguanodon mantelli*, and *Camptosaurus* (*Iguanodon*) *prestwichii* all have unpaired parietals.

Seen from above the parietals are comparatively short, heavy bones. Their lateral surfaces, which form the upper walls of the brain case, are smooth, concave antero-posteriorly and thus constricted medially into a rounded crest, and without the sharp median sagittal ridge found in *Iguanodon*. Anteriorly the expanded end unites with the broad plate-like frontals by an angular suture. Laterally a prolongation of the anterior portion of the parietal curves outward to meet the postfrontals, and with these bones form the upper anterior boundary of the supratemporal fossa. Similarly the postero-lateral border turns outward, joining the squamosal with which it bounds posteriorly the upper opening of the fossa. Ventrally it encloses the upper portion of the supraoccipital. In the skull of *C. medius*, No. 1880, Yale Museum, the parietal has a transverse width of 51 mm. at its middle. There is no parietal (pineal) foramen in *Camptosaurus*.

*Squamosal*.—The following description of the squamosal of *Camptosaurus*, found among Professor Marsh's unpublished notes, is based on the left element of *C. medius*, No. 1880, Yale Museum.

The squamosal fits very snugly on the head of the quadrate, and probably excludes the quadrate entirely from touching the paraoccipital process as in *Sphenodon*. In position it is most nearly related to that of *Iguana*. It has four distinct processes. The postfrontal process is very thin, flat, and arched outward above. The sutural surface is rather more than  $1\frac{1}{2}$  inches in length, reaching to within a half inch of the tip of the quadrate. The head of the quadrate fits closely into a pit on the under surface. A slender process runs downward along the anterior exterior border of the quadrate containing the articulation for a third of the entire length. This corresponds in position to the same process on *Sphenodon* that runs down to articulate with the quadratojugal. In the present case it is much more slender and probably does not reach that bone.

The parietal process extends inward along the dorsal border of the paraoccipital process to meet the outward-turned process of the parietal, the two forming the upper posterior border of the supratemporal fossa as in *Stegosaurus*.

*Frontals*.—Viewed from above the paired frontals are irregularly five-sided bones, longer than wide, with a flattened, smooth dorsal surface. Posteriorly they unite with the parietal and postfrontals, and externally with the post- and prefrontals. The postfrontal border is convex instead of concave and extends anteriorly much farther than as first indicated by Marsh. The prefrontal border extends diagonally from the external border to the middle of the anterior end. A short, smooth surface between the anterior and posterior

<sup>a</sup> Phil. Trans. Royal Soc. London, CLXXIII, 1882, p. 1037.

extremities of the post- and prefrontals on the external border contributes to the inner boundary of the supraorbital fossa, but to no such extent as shown in Plate 53, fig. 2, in "Dinosaurs of North America." The orbital surface is large and concave antero-posteriorly in Cat. No. 5473, U.S.N.M., being separated from that of the opposite side by an intermediate space of 30 mm. The internal median ventral surface is separated from the orbital surface by an irregular, longitudinal ridge. This internal surface constitutes the roof of the anterior part of the brain case for the reception of the olfactory lobes.

*Postfrontal*.—The postfrontal is a three-rayed bone, and resembles that of the *Monitor* most nearly, but its union is chiefly with the frontals. One short, heavy ray articulates with the postero-external angle of the frontal and forms part of the anterior boundary of the supratemporal fossa. A slender, posteriorly directed ray articulates by a long, lapping suture with the anterior branch of the squamosal and with that bone completes the upper temporal bar which forms the outer boundary of the supratemporal fossa. The third ray, the longest of the three, unites by its strong descending process with the jugal and thus forms the posterior border of the orbit. This process below is trihedral in cross section.

*Prefrontal*.—The presence of a prefrontal is plainly indicated in two specimens in Yale Museum, Nos. 1880 and 1887. It is the lower external surface of this bone which gives the main support to the supraorbital and its posterior outer border forms a part of the internal boundary of the supraorbital fossa. This element, as preserved in the above specimens, is too mutilated for detailed description.

*Quadrate*.—I quote the following description from Professor Marsh's unpublished notes, kindly placed at my disposal by Prof. R. S. Lull, of Yale University Museum:

The quadrate resembles most nearly that of *Iguana* but more slender. From the side the posterior border is concave and above the middle is rather thin. The posterior "hamular" process of the head is quite thin. The surface for the pterygoid is large and hollowed and formed by thin bone. The articulation for the jaw is rectangular in outline and but slightly convex. From the front it is concave transversely throughout its whole length, deeply above, more shallow below.

Plate 9, fig. 2, shows the long, finger-like process of the pterygoid which extends backward and laps along a thin, forwardly directed process on the inner surface of the lower part of the quadrate. The quadrate in the skull of *C. medius*, No. 1880, Yale Museum, is 115 mm. in length. The external view of this bone is well shown in fig. 2, *qu*. In *Camptosaurus* the quadrate is more curved and lighter than the corresponding element in *Iguanodon*.

*Quadratojugal*.—The presence of this element is plainly indicated in specimen No. 1887, Yale University Museum (see Plate 8, *qj*).



It is a thin, subtriangular plate of bone which meets the jugal anteriorly by a curved but nearly vertical suture. The greater portion of this bone overlaps the median external surface of the quadrate. It is entirely excluded from the boundary of the infratemporal fossa by an ascending branch of the jugal.

*Jugal*.—The jugal is rather a wide bar posteriorly and is connected above with the descending process of the postfrontal and by an ascending process posteriorly with the quadratojugal and quadrate. It is not certainly known that this process reached the descending process of the squamosal as indicated in the restored skull. A curved, forwardly directed continuation of the jugal completes the lower boundary of the orbital opening, and undoubtedly articulates with the lachrymal, although this point could not be determined from actual observation. The above description is of the left jugal of No. 1887, Yale Museum.

*Nasals*.—The nasals are very large, subtriangular bones, which form a considerable part of the upper surface of the skull. They unite posteriorly with the frontals and prefrontals and laterally with the posterior process of the premaxillæ, and slightly with the prefrontal. Their concave anterior ends form most of the posterior boundary of the external nares. They terminate anteriorly on the median line as two points which meet the superior and posteriorly directed processes of the premaxillæ. In skull No. 1887, Yale Museum (see Plate 7), the suture separating the nasals is distinctly shown anteriorly.

*Lachrymals*.—The lachrymals are thin plates of bone wedged in between the maxilla, premaxilla, jugal, and prefrontal. They may have been slightly overlapped by the supraorbitals. They form part of the anterior boundary of the orbits. These bones were found *in situ* in specimen No. 1887, Yale University Museum (see Plate 7, l.).

*Supraorbital*.—The supraorbital has an expanded proximal articular end. Posteriorly it tapers rapidly to a small, nearly round extremity which remains free as in *Iguana*. The proximal end is roughened and deeply cleft, forming two surfaces which meet in the middle at an obtuse angle. When in position these faces are opposed to the lateral surfaces of the prefrontal and lachrymal (?), as shown in Plate 7. It forms the external boundary of the supraorbital fossa, as in *Iguanodon bernissartensis*. There is no indication of a posterior supraorbital in *Camptosaurus* as found in *Iguanodon*. In No. 1880, Yale Museum, the widest part of the supraorbital fossa was 14 mm. between the posterior end of the supraorbital and the exterior border of the frontal. Marsh's drawing of this region of the skull appears to be erroneous, as will be noticed by an examination of the reconstructed skull of *Camptosaurus medius*, in the Sixteenth Annual Report of the U. S. Geological Survey, Part II, Plate 53, figs. 1 and 2, the fossa being too large, and incorrectly designated as orbit.



*Premaxillary*.—Two specimens, Nos. 1880 and 1887, Yale Museum, have the premaxillæ preserved, and the following description is based upon their study:

In *Camptosaurus* the premaxillæ are edentulous. The dentigerous surface anteriorly is expanded transversely, but posteriorly it contracts and sends backward and upward a thin, flat process which is intercalated between the maxillary and nasal. The posterior termination appears to reach the prefrontal and has been so indicated in the restoration shown in fig. 2. I am inclined to believe it did not extend quite so far posteriorly as Marsh has indicated in his reconstruction of the skull.

A regularly curved subtriangular process rises from the antero-superior surface and forms the upper boundary of the narial orifice. Medially it is closely applied to its fellow of the opposite side but not ankylosed. Thickened below, it gradually tapers upward to a point which meets the anterior extremity of the nasal at the summit of the external nares. The external surface of this process is very

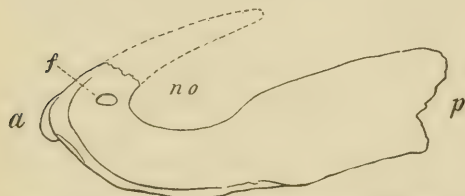


FIG. 6.—OUTLINE OF LEFT PREMAXILLARY OF *CAMPTOSAURUS MEDIUS* MARSH. NO. 1880, YALE MUSEUM;  $\frac{1}{2}$  NAT. SIZE. HOLOTYPE. *a*, ANTERIOR END; *f*, FORAMEN; *no*, NASAL ORIFICE; *p*, POSTERIOR END.

rugose and, like the rostral bone of *Triceratops*, was doubtless covered with a horny sheath which opposed a like covering over the prementary. At the base of this superior process is an oval foramen (see fig. 6, *f*), which pierces the bone, and appears on the ventral surface. The left premaxil-

'ary of No. 1880, Yale Museum, has a dentigerous surface 51 mm. in length. The greatest width of the expanded ends of the premaxillæ in this specimen is 41 mm. On either side of the median junction of the anterior ends are small rounded protuberances, separated medially by a shallow cleft.

The principal characters of the premaxillary are well shown in Plate 7, fig. 1.

*The maxillary*.—As shown in fig. 7, the general outline of the maxillary is that of an irregular triangle. Dorsally it develops a slender, backwardly directed process which, in No. 1886, Yale Museum, rises to a height of 59 mm. above the external dentigerous margin. From the posterior base of this ascending process, the upper border gradually descends to 20 mm. above the last tooth.

Throughout nearly the whole length of the external surface, some 10 to 12 mm. above the border, the maxilla is pierced by a series of foramina. None of these, however, lead into the dental chamber but are received in a large, elongate cavity situated at the base of the

dorsal process between the thin inner and outer walls, and which opens posteriorly. The foramina, in passing through the outer wall, are directed obliquely backward and appear to leave the maxillary posteriorly through a common channel or groove on the superior surface of the inner shelf-like projection of this part of the bone. This is well shown in the left maxillary of Cat. No. 5818, U.S.N.M. They probably transmitted the nerves and blood vessels leading to the lips. Above this row are still other irregularly placed foramina as shown in fig. 7. The slightly concave dentigerous surface in No. 1886 has alveoli for 16 teeth. In advance of the most anterior tooth a thin, flattened process is sent forward which underlies the posterior ascending process of the premaxillary. Viewed from above the maxillary remains about the same width throughout the median part, but the inner border of the posterior end is diagonally truncated. On the internal side just above the tooth row is another series of foramina which probably transmitted nerves and nourishment to the teeth.



FIG. 7.—LATERAL VIEW OF LEFT MAXILLARY OF CAMPTOSAURUS. No. 1886, YALE MUSEUM.  
 $\frac{1}{2}$  NAT. SIZE.

The exact relationships of the maxillary to the surrounding elements can not be determined further than what is shown in fig. 2.

#### EXTERNAL OPENINGS IN THE SKULL.

*Foramen magnum.*—The foramen magnum is large as compared with the size of the brain cavity, suboval in outline, being wider above than below, the longer diameter being vertical. It is bounded below by the basioccipital, on either side by the exoccipitals, and above by the supraoccipital (see fig. 4, *fm.*).

*Supratemporal fossæ.*—The supratemporal fossæ are situated one on either side of the parietals. They are bounded anteriorly by the postfrontals and parietals; internally by the parietals; posteriorly by parietals and squamosals; externally by the squamosals and a posterior prolongation of the postfrontals. These openings are proportionately much larger and more elongate than in *Stegosaurus*.

*Supraorbital fossa.*—The supraorbital fossa is bounded anteriorly by the prefrontal and supraorbital; posteriorly by the postfrontal;

externally by the inner surface of the supraorbital. It is not certainly known whether the external border was entirely closed by the development of a post-supraorbital as found in *Iguanodon bernissartensis*. So far as I am aware, *Camptosaurus* is the only American dinosaur having such a fossa. When skulls of *Laosaurus* and *Dryosaurus* are known, similar openings will probably be found.

*Infratemporal fossa*.—The infratemporal fossa is bounded above by the posterior branch of the postfrontal; behind by the descending process of the squamosal and ascending process of the jugal; below by the jugal, and in front by the ascending and descending process of the jugal and postfrontal, respectively. Proportionately this fossa has no such development as is found in *Iguanodon*, where it is greatly elongated dorso-ventrally.

There are no preorbital fossæ.

*Orbital cavities*.—As indicated by the extent of the orbital surfaces on the postfrontals of Cat. No. 5473, U.S.N.M., these cavities must have been of good size. Their exact contours, however, are somewhat problematical, as none of the crania studied have the boundaries of the orbits intact, but, as interpreted, the reconstructed skull (see *o*, fig. 2), which was drawn after a careful study of all available material, is believed to be a fairly accurate representation of their shape and size. They are bounded above on the outer margin by the supraorbitals and postfrontals; behind by the descending process of the postfrontals and ascending process of the jugals; below by the jugals; in front by the jugals, lacrymals, and supraorbitals. There is no indication of a postorbital in *Camptosaurus*.

*The narial opening*.—The narial opening is well shown in No. 1887, Yale Museum (see Plate 7), after which this region of the figured skull was drawn. It is of good size, suboval in outline, with its greatest diameter inclined to the longer axis of the skull, as in *Iguanodon bernissartensis*. Excepting the posterior border, which is formed by the nasals, the remainder of the orifice is inclosed by the premaxillaries. Anteriorly, the roughened ascending process of the premaxillaries roof over somewhat the lateral openings.

*Lesser foramina*.—The well preserved posterior portion of the skull of Cat. No. 5473, U.S.N.M., shows with unusual clearness the smaller foramina of this region (see figs. 4 and 5). By a comparison with the foramina in other reptilian skulls of both fossil and recent forms, and by examining the relations of the various foramina to one another, it is believed they have been determined with a considerable degree of accuracy.

Beginning with the most posterior, we find on the lower lateral margin of the exoccipital a pit-like depression, from the bottom of which two foramina pierce the exoccipital, entering the brain case just within the external opening of the foramen magnum (see XII, figs. 2 and 5). In passing through the wall they diverge somewhat,



their internal openings being 5 mm. apart, the anterior being the smaller and occupying a more ventral position. It was first thought that both of these foramina belonged to the hypoglossal, and I find that Andrews<sup>a</sup> has so interpreted similarly placed openings in the skull of *Iguanodon*, although he suggests that the spinal accessory may have occupied one. Hatcher<sup>b</sup> considers that in *Triceratops* the two posterior foramina transmitted the XII and XI nerves.

I am inclined to the opinion, however, that the second and more ventrally placed foramen was for a vein, as found in the living crocodile, the first being the true hypoglossal foramen (see XII, fig. 5). A few millimeters anterior to the opening for the twelfth nerve is a third foramen, shown IX and X, fig. 5, which is identified as the foramen lacerum posterius, through which the pneumogastric, vagus, and glossopharyngeal nerves were transmitted. This foramen extends forward diagonally through the exoccipital, passing out on its anterior border into a large foramen (see VIII, fig. 5), between the exoccipital, opisthotic, and prootic, just before the latter enters the brain case. Externally the foramen lacerum posterius is separated from the foramina posteriorly by a weak vertical ridge, and anteriorly by a heavier rounded ridge which rises near the base of the exoccipital and extends diagonally upward and backward, fading out on the lower border of the paraoccipital process. Six millimeters anterior to the foramen lacerum posterius is another small foramen which passes through the antero-external corner of the exoccipital, and also opens into the large foramen mentioned above. Its function, however, is unknown.

From the position of the large foramen (VIII, fig. 5), bounded principally by the otic bones, I identify it as the internal auditory meatus, through which the auditory nerve leaves the cranial cavity and enters the internal ear. This interpretation appears to be approximated in the long, slit-like internal auditory meatus in extant *Crocodyla*, which is also bounded by the opisthotic, prootic, and exoccipital. As in the crocodile, there is no ossified division of this opening into the fenestræ ovalis and rotunda.

Eight millimeters anterior to the internal auditory meatus, a small foramen pierces the median part of the prootic which is considered the exit of the seventh or facial nerve (see VII, fig. 5). Below, a deep, vertical depression leads up to this foramen from the slit-like fissure on the lateral border of the basisphenoid through which the carotid enters the pituitary body.

Huxley<sup>c</sup> writes that in all higher Vertebrata "the third division of the trigeminal or fifth nerve always leaves the skull behind the

<sup>a</sup> Annals and Magazine of Natural History, 6th ser., XIX, 1897, p. 590.

<sup>b</sup> Mon. U. S. Geol. Surv., XLIX, 1907, pp. 36, 37, fig. 31.

<sup>c</sup> Anatomy of Vertebrated Animals, 1872, p. 70.



center of the alisphenoid and in front of the pro-otic." Following this definition it locates at once the foramen ovale as the large opening (V, fig. 5) between the union of the alisphenoid and prootic, which is largely inclosed by the prootic, the alisphenoid forming only the anterior boundary. In assigning a similarly placed foramen to the third nerve in a skull of *Hypsilophodon*, Hulke<sup>a</sup> appears to be in error.

The determinations of the foramina of this region differ somewhat from those of Andrews<sup>b</sup> for the skull of *Iguanodon*, due to the different arrangement of the foramina entering the foramen lacerum posterius, *Iguanodon* having both an anterior and posterior branch instead of being single as in *Camptosaurus*.

The pituitary fossa is deep, extending considerably below the floor of the median vesicle. Its ventral posterior angles mark the positions where the internal carotids enter the cavity diagonally from deep external fissures on the sides of the basisphenoid shown at *c*, fig. 5.

None of the skulls studied show the relations of the foramina anterior to those for the branches of the trigeminal or fifth nerve.

It is unfortunate that there is not a brain case sufficiently complete from which a cast of the brain cavity might be made, for it would show at once the great similarity to the brain of *Iguanodon* as described by Dr. C. W. Andrews. The ventral surface of the supraoccipital of Cat. No. 5473, U.S.N.M., if cast would show the same compressed cerebellum rising high above the hemispheres. This high dorsal development of the brain appears to be peculiar to *Camptosaurus* and *Iguanodon*, although there is a suggestion of it in the brain casts of some of the trachodont reptiles.

#### THE LOWER JAW.

A complete jaw of *Camptosaurus* is unknown, but a study of well preserved parts, representing several individuals which supplement one another, shows that each ramus is formed of seven separate bones, the two rami being joined anteriorly by a prementary. The arrangement of the bones of the posterior half of the ramus are admirably shown in No. 1887, Yale Museum (see Plates 8 and 9), and the description of this region is based principally upon a study of this specimen.

*The dentary.*—The dentary which forms the anterior half of the jaw is the largest of the elements composing it and bears along the outer part of its dorsal border aveoli for 15 teeth—on the inside 16 can be counted (see 2, fig. 8). Anteriorly it is somewhat com-

<sup>a</sup> Quart. Journ. Geol. Soc. London, XXXVI, 1880, p. 435.

<sup>b</sup> Annals and Magazine Natural History, 6th ser., XIX, p. 590.

pressed transversely with a part on the lower border of the anterior end, which curves in and was united with the dentary of the opposite side by cartilage only (see *ss*, fig. 8). Hulke's description of the anterior part of the mandible of *Hypsilophodon* as having a "spout-like symphyseal end" aptly describes this region in *Camptosaurus*. Posterior to the symphyseal surface the dentary swells somewhat transversely, but remains about the same depth throughout the dentigerous part, the upper and lower borders being nearly parallel. The lower border is almost straight, as shown in fig. 8. A short, blunt process rises from the dorsal surface just posterior to the last

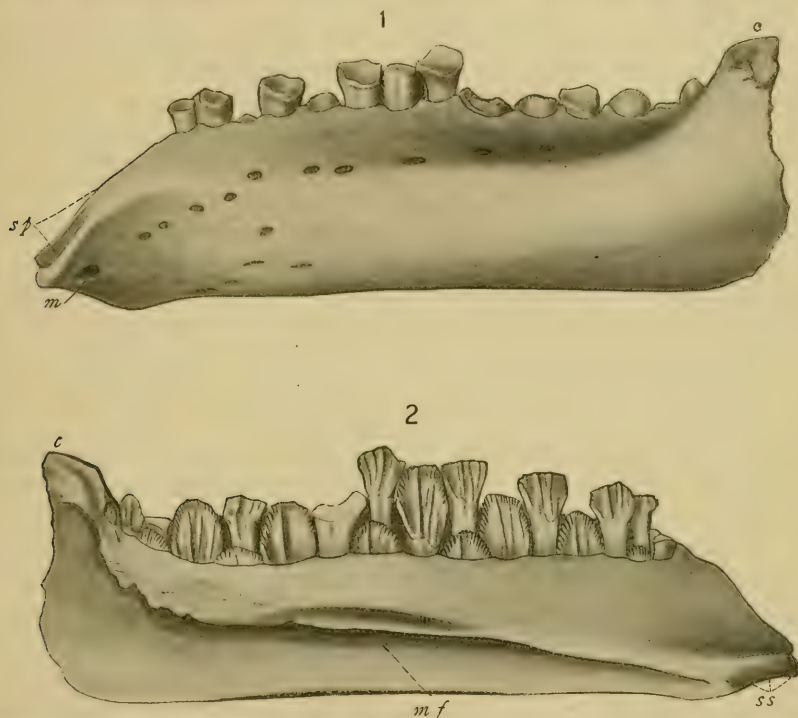


FIG. 8.—(1) EXTERNAL VIEW OF LEFT DENTARY, CAMPTOSAURUS. NO. 1886, YALE MUSEUM,  $\frac{1}{2}$  NAT. SIZE. *c*, CORONOID PROCESS; *m*, MENTAL FORAMEN; *sp*, SURFACE FOR PREVENTARY. (2) INTERNAL VIEW OF SAME. *c*, CORONOID PROCESS; *mf*, MANDIBULAR FORAMEN; *ss*, SYMPHYSEAL SURFACE.

tooth and gives support on the internal side to the coronoid (see *c*, fig. 8).

Just beneath the base of the coronoid process there is a deep cavity (*mf*., 2, fig. 8) opening on the infero-internal surface of the dentary and extending forward nearly its entire length. This mandibular fossa is present in most reptilian jaws, and in *Camptosaurus* is inclosed principally by the overlapping splenial. Posteriorly the dentary is in contact with the angular, surangular, and prearticular. The dentary unites with the prementary by an oblique surface on the

anterior end, commencing dorsally just anterior to the aveoli of the most anterior tooth, and terminating ventrally in a point above the lower border of the dentary. A concave ventral surface posterior to the anterior point or projection on the inward extension of the dentary, for cartilaginous union with its fellow of the opposite side, apparently represents a surface for the reception of a posterior branch of the predentary after that found in *Stegosaurus* and *Triceratops*.

On the outer side of the dentary, about 20 mm. below the superior border, there is a series of foramina that extends the length of the bone. These doubtless served for the transmission of nerves and nutrient blood vessels to the lips.

The largest foramen on the external surface near the lower anterior end of the dentary at *m*, 1, fig. 8, probably represents the mental foramen through which a branch of the fifth nerve emerges.

The more important characters of the dentary of *Camptosaurus* are well shown in fig. 8, drawn from the left dentary of No. 1886, Yale Museum.

*Surangular*.—Externally the surangular meets the dentary and coronoid (?) just posterior to the coronoid process by a nearly vertical suture, and forms the upper border of the jaw, extending backward and downward to its posterior extremity. Ventrally it unites for its full length with the superior border of the angular. Its upper posterior surface is excavated and forms the external part of the cotylus for the articulation of the quadrate. There is a pronounced external mandibular foramen (see *sf*, fig. 2) on the outer median surface just posterior to its union with the dentary, as in *Triceratops prorsus* and *Iguanodon bernissartensis*.

*Angular*.—The angular forms the lower portion of the posterior third of the ramus, being wider in front than posteriorly. On the external surface, anteriorly, it is overlapped by a broad, thin, posterior finger-like prolongation of the dentary, as shown in figs. 1 and 2, Plate 8. Dorsally it meets the surangular and prearticular, and in conjunction with these elements, inclosed and held in position the small, block-like articular. On the anterior internal side it is overlapped by a posterior prolongation of the splenial. (See Plate 9.)

*Articular*.—The articular is a block-like bone higher than wide, and, as in many reptiles, when in position was probably the most posterior element of the mandible. In No. 1887, Yale University Museum, as shown by fig. 1, Plate 9, the articular has been crowded up and forward from its normal position in the jaw. It could not be determined whether there was an anterior prolongation of this bone lying between the prearticular and supra-angular, as this region is still enveloped in a hard sandstone matrix.

*Prearticular*.—In specimen No. 1887, Yale Museum, there was found to be an extra element on the postero-internal side of the



ramus, which, from its position, I have identified as the prearticular. Marsh considered this bone the articular, as is indicated by the abbreviation "art." still remaining on the specimen and plainly shown in fig. 1, Plate 9, reproduced here from a photograph. This interpretation, however, leaves the small element on the supero-posterior part of the jaw without designation. That these two bones are distinct elements there can be no question, as all of the sutures in this specimen are clearly defined, and, moreover, the posterior part of the ramus of No. 1880, Yale Museum, shows the articular in position while the prearticular has been displaced and is missing.

Dollo<sup>a</sup> considers an element occupying a similar position in the jaw of *Iguanodon bernissartensis* the surangular. I am inclined to believe that this element represents the prearticular and that the surangular is on the supero-external part of the posterior end of the ramus, as in *Camptosaurus*, but which he indicates as the articular. The presence of an external mandibular foramen occupying relatively the same position as found in the surangular of *Camptosaurus* (see fig. 2, *sf*) is also suggestive of the correctness of this interpretation.

In *Camptosaurus* the prearticular is an elongate bone lying dorsal to the supero-internal border of the angular, and extending nearly if not fully to the posterior termination of the jaw. Anteriorly its forward extremity is covered by the overlying splenial. Its upper posterior border is concave and, with the surangular and articular, forms a cotyloid surface for the quadrate. In comparison with the size of the end of the quadrate this surface is capacious, an arrangement which would have permitted of free movement of the jaws upon the quadrate. On the internal median surface, just before this element disappears under the splenial, may be seen an elongated oval foramen, which probably represents the internal mandibular foramen of most reptiles (see *f*, Plate 9, fig. 2). I do not know that this element has been observed before in a member of the orthopodous dinosaurs, although it is present in most turtles and members of the Pelycosauria, and it would appear to indicate a primitive arrangement of the elements of the mandible.<sup>b</sup>

*Splenial*.—The splenial is a comparatively thin, flattened bone applied to the inner surface of the ramus. On the lower posterior

<sup>a</sup> Dollo, Bull. Bruxelles Mus. Roy. d'Hist. Nat. de Belgique, II, 1883, pl. ix, fig. 3.

<sup>b</sup> Williston gives an interesting discussion of this element in his description of *Dolichorhynchops* (Field Columbian Mus. Pub. No. 73, Geol. Ser., II, No. 1, 1903, pp. 29 to 32). He calls attention to the fact that Baur (Amer. Nat., 1891) believes that the element usually considered the articular is composed of two bones in the young *Sphenodon* and the conditions found in the jaws similar to those of the Testudinata. Baur assumes these elements to be present in all reptilian mandibles, but in the adult skull their identity becomes obliterated by the ankylosis of the suture.



border it sends back a thin, finger-like process which laps along the anterior internal surfaces of the angular and prearticular. From an examination of mutilated specimens it appears there was a long tapering anterior process which covered over the mandibular fossa in the dentary, and extended nearly to the anterior symphysial end. It met the coronoid by a horizontal suture below the level of the functional teeth (see fig. 2, Plate 9). The median ventral border is swollen transversely and extends below the dentary and angular, and is visible from a lateral view of the mandible.

*Coronoid.*—The coronoid is a small, flattened bone roughly triangular in outline. It unites ventrally with the splenial, dentary, and surangular, and the lower external surface laps along the internal surface of the short dorsal process of the dentary, extending above it and terminating in a compressed, rounded end. Its general outline is shown at *co.*, fig. 2, Plate 9.

*Predentary.*—The predentary is unknown, but after a comparison of camptosaurian remains with those of allied forms, I am inclined to the opinion that when found it will be more after the pattern of *Iguanodon* than of *Triceratops*, as Marsh has indicated it in the first restoration of the mandible. In the restoration of the skull (see

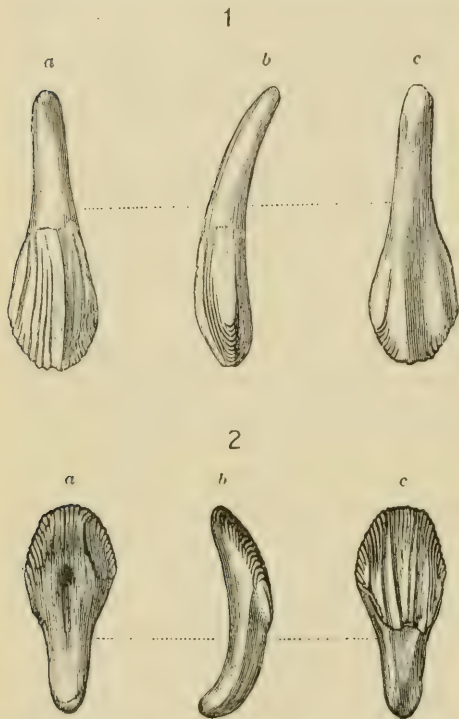


FIG. 9.—(1) TENTH UPPER TOOTH; (2) FIFTH LOWER TOOTH OF CAMPTOSAURUS MEDIUS MARSH. No. 1880, YALE MUSEUM. HOLOTYPE. NAT. SIZE. *a*, OUTER VIEW; *b*, VIEW OF POSTERIOR BORDER; *c*, INNER VIEW. AFTER MARSH.

fig. 2), the predentary as drawn is a modification of that of *Iguanodon*.

*The teeth.*—The teeth of both upper and lower jaws when unworn are spatulate with serrated margins. A representative tooth selected for description from the maxilla measures 38 mm. in length, of which 19 mm. belong to the crown. The root is cylindrical, gradually tapering from the base of the crown to its end. As shown by broken teeth, there was a large pulp cavity extending well up into the crown. The outer surface of the upper and the inner surface of the lower teeth are sculptured by longitudinal ridges passing from the union of the

crown and root to the upper border of the former. Every tooth shows one pronounced longitudinal ridge, which is always, whether it be upper or lower, posterior to the median line, having on each side a varying number of secondary ridges (fig. 9). There are more of the secondary anterior to the main ridge than there are posterior. The secondary ridges are also more numerous and stronger in teeth of the upper than in those of the lower jaw, a character which serves to distinguish detached teeth. Many of these ridges subside before reaching the base of the crown; none are serrated as is the case in the teeth of *Iguanodon*. The teeth at either end of the dental series, whether it be upper or lower, are slightly smaller than those intermediate. The contour of the larger teeth appears to be less angular than the smaller. Both upper and lower teeth are curved longitudinally, this curvature inclining the crowns of the upper teeth inward to meet those of the lower jaw, which are similarly inclined outward. Nearly all crowns which project fully above the level of the outer border of the alveolar process show marks of wear, being obliquely ground. The ridged surface, having thick enamel, stands longer and forms a cutting edge, which at first is serrated, but later becomes sinuous as the longitudinal ridges become cross sectioned. The inner surfaces of the crowns are smooth, gently convex antero-posteriorly, and unsculptured, the terminal marginal serration showing slightly upon it. When much worn these spatulate teeth are reduced to flattened stumps, as shown in the figures. Hulke<sup>a</sup> says of the teeth of *Hypsilophodon*:



FIG. 10.—INTERNAL VIEW OF RIGHT DENTARY. CAMPTOSAURUS DISPAR? MARSH. CAT. NO. 5819, U.S.N.M.  $\frac{1}{2}$  NAT. SIZE.  
a, ANTERIOR END; d, DENTARY; p, POSTERIOR END.

“By the time the crown is worn to the level of the alveolar border of the jaw, the tapering cylindroid root has been absorbed, so that a very slight force would suffice to detach the remnant in this condition.” In *Camptosaurus*, however, they appear to be forced out before the absorption of the root, as will be seen by an examination of figs. 8 and 10.

The arrangement of the teeth in a longitudinal and vertical series is well shown in figs. 8 and 10. Successional teeth in the dentary are seen below and between those of the functional row. In the maxillae these teeth descend as usual on the inner side of those in use. Thus, in the upper jaw they replace on the unsculptured and in the lower

<sup>a</sup> Phil. Trans. Roy. Soc. London, CLXXIII, 1882, p. 1042.

on the sculptured sides of the functional teeth. There appears to be only two teeth in a single vertical series. In the dentary of Cat. No. 5819, U.S.N.M. (see fig. 10), four phases of the successional teeth are shown, (1) stumps about to be shed, (2) teeth whose crowns are in full wear, (3) germ crowns which have only partly emerged and not yet in use, (4) tips of germ crowns just appearing above the inner parapet.

The dentary, as shown by several individuals, bears from 14 to 16 teeth, and the maxillary probably an equal number. As shown in figs. 8 and 10, the teeth appear to rise as two or more oblique rows, those posterior being the higher in each row. None of the jaws studied show the regular arrangement of the teeth found in *Iguanodon*, as figured by Dollo.<sup>a</sup>

All of the maxillæ and dentaries examined show a great irregularity of the functional row as exhibited in figs. 7, 8, and 10.

Nicholson and Lydekker<sup>b</sup> were the first to point out that the teeth of *Camptosaurus* "were somewhat similar in their structure to those of *Iguanodon*," but by most authorities they are considered simpler in their sculpturing.

*Hyoid*.—That there is a well-developed hyoid in *Camptosaurus* is shown by specimen No. 1887, Yale Museum (see *h*, fig. 2, Plate 9), which has the thyrohyal of the left side preserved nearly *in situ*. It is an irregularly rounded curved bar with a slightly expanded, rounded, anterior extremity. Posteriorly it gradually tapers to a small, smooth, round end. Marsh<sup>c</sup> has called attention to the resemblance of this element to the hyoid in *Iguanodon*.

The principal measurements of this element of a very large individual are as follows:

	mm.
Greatest length.....	152
Greatest width of anterior end.....	18
Greatest width of posterior end.....	7

#### THE VERTEBRAL COLUMN.

As nearly as can be determined, the vertebral formula of *Camptosaurus* is as follows: Cervicals, 9; dorsals, 16?; sacrals, 4 or 5; caudals, 44+. There are no true lumbar.

In giving the formula as above, the cervicals may be considered absolutely determined, as shown by complete necks in four different individuals. Specimens Cat. Nos. 4282 and 2210, U.S.N.M., agree in having 16 dorsals, the most posterior of which is modified to give some support to the first sacral rib, and should properly be considered a sacro-dorsal. I have considered as sacrals

<sup>a</sup> Bull. Bruxelles Mus. Roy. d'Hist. Nat. de Belgique, II, 1883, pl. ix, fig. 3.

<sup>b</sup> Manual of Paleontology, p. 1159.

<sup>c</sup> Amer. Journ. Sci., XLVII, 1894, p. 246.



only those vertebrae which support sacral ribs, and this interpretation does not include all of those sutured by their centra in adult individuals, as will be discussed later. In the two specimens referred to above, there are preserved 33 and 34 caudals respectively, and I have estimated that probably nine or more would be required to complete the series. In regard to the caudal series in *Camptosaurus*, it appears to agree approximately with the number found in complete specimens of *Iguanodon*, which varies from 46 to 48.

*The atlas.*—The atlas is composed of four separate pieces, the intercentrum, two neural arches or neuracentra, and the odontoid process. The intercentrum is a subcrescentic block of bone, the longer axis being transverse. Viewed from above, the median surface is concave, forming a hollow in which the anterior rounded portion of the odontoid rests. The anterior part of this concave surface is more deeply excavated, forming a shallow, transverse groove in which a corresponding ridge on the antero-inferior surface of the odontoid fits. On either side of the median depression are the articular faces which look upward and outward, and on which the pedicles of the neuracentra rest. The posterior view presents a nearly vertical face, rounded only on the median inferior border. Inferiorly and on either side are well developed facets for the articulation of the cervical ribs of the atlas. The anterior face superiorly is deeply excavated, forming the lower portion of the cup for the reception of the occipital condyle, the anterior border being lip-like where it underlaps the articular surface of the condyle.

None of the specimens studied has the upper expanded ends of the neuracentra complete. The articular end is about evenly divided into two faces which meet at an obtuse angle. The posterior face rests upon the intercentrum, while the other looks forward and downward and forms part of the cup for the occipital condyle. Above the articular end just described, the shaft is constricted, but superior to this neck it widens again, but as to its further extent the available material shows this part to be lacking. As in other dinosaurs, the neuracentra articulate posteriorly with the anterior zygapophyses of the axis.

The *odontoid* is slightly cupped posteriorly, and though closely applied to the axis, shows no indication of coalescence in any of the specimens studied. The upper surface forms the floor of the neural canal and is slightly concave transversely. The anterior half of the odontoid is slightly constricted, forming a short neck (see 1, fig. 11). Inferiorly the surface is rounded, the posterior half having a smooth, transversely rounded articular surface which is in contact with the upper concave surface of the intercentrum. The smooth anterior end is rounded both vertically and horizontally where it abuts against the posterior end of the occipital condyle. In passing,



it may be of interest to note that the atlas of *Stegosaurus* is, in nearly all respects, very similar.

*Measurements of atlas, Specimen Cat. No. 5473, U.S.N.M.*

	mm.
Greatest length of intercentrum antero-posteriorly-----	23
Greatest width of intercentrum-----	58

*The axis.*—The axis of specimen Cat. No. 5473, U.S.N.M., as preserved is fairly complete, and it is upon this that the following detailed description is based, although many of the facts are supplied from the incomplete axes of Cat. Nos. 2210 and 5474, U.S.N.M., and 1877, the holotype of *C. dispar*, in the Yale University Museum.

The centrum is plano-concave, the cup being moderately deep. Medially the centrum is constricted both laterally and inferiorly but without ventral keel. The anterior extremity is more expanded laterally than the posterior, the width of the former exceeding the total

length, as shown in fig. 12. On the lateral median surfaces are two small vascular foramina. These are not present, however, in the axis of Cat. No. 5474, U.S.N.M., but are represented by shallow cavities or depressions.

The neural arch is composed of two parallel plates of bone, which, as they rise from the centrum, gradually converge, uniting above and forming a sharp median longitudinal crest. Transversely the neural

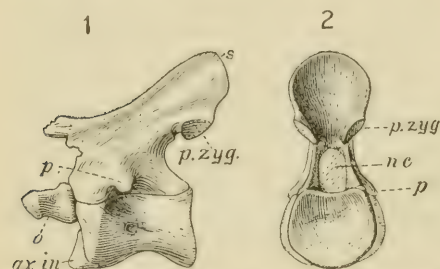


FIG. 11.—(1) AXIS AND PORTION OF ATLAS OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5473, U.S.N.M., SIDE VIEW,  $\frac{1}{4}$  NAT. SIZE; (2) POSTERIOR VIEW OF SAME; *ax. in*, SECOND INTERCENTRUM; *nc*, NEURAL CANAL; *o*, ODONTOID; *p*, DIAPOPHYSES; *p. zyg.*, POSTZYGAPOPHYSES; *s*, NEURAL SPINE.

spine is compressed, but it extends out over the centrum at either end, more especially the posterior (see fig. 11). This portion of the spinous process rises somewhat and flares out into a comparatively thin frill-like plate which overhangs the centrum of the succeeding vertebra. Posterior zygapophyses, which look downward and outward, are well developed on the lower borders of the overhanging part. The anterior prolongation of the spinous process is hardly more than an anterior development of the median crest. Although it appears that the anterior zygapophyses were probably present, this part of the bone in all of the specimens studied is damaged, and their shape and position could not be determined.

A weak diapophysial process which extends outward and downward (see *p*, fig. 11), is developed on the median, infero-lateral sur-

face of the pedicle of the arch. Viewed posteriorly the neural canal is subelliptical in outline, the longer axis being vertical.

The most striking feature of the axis is the presence of a second intercentrum firmly co-ossified with the inferior surface of the anterior extremity of the centrum. Attention has been called to this element in a former paper <sup>a</sup> as follows:

In comparing the axis of *Morosaurus agilis* with the homologous parts of other Dinosaurian specimens in the U. S. National Museum, the writer found, on the axes of two individuals of the genus *Camptosaurus*, intercentra attached by suture to the centra of the axes. So far as the writer is aware, this element has not been observed before in a representative of the Orthopoda. In the smaller (No. 5474, U.S.N.M.) and probably younger specimen the intercentrum has been somewhat crushed out of position, but in the larger specimen (No. 5473, U.S.N.M.) it is retained in place. \* \* \*

Inferiorly the intercentrum of *Camptosaurus* is roughly subelliptical in form, the longer axis being transverse. It is closely united by suture to the lower half of the anterior end of the centrum, forming a prominent lip-like projection which, when articulated, underlaps somewhat the centrum of the atlas [see fig. 12]. In a fully adult specimen this element would probably become coossified, as in *Morosaurus grandis*, and thus lose its identity. Viewed from the side, it is triangular in form, the deepest portion being next to the centrum. The inferior surface is gently convex transversely and slightly concave antero-posteriorly. Seen from the front, the center has the greatest vertical depth, the upper margins gradually sloping down to the lateral borders. The anterior face is smooth and somewhat concave supero-inferiorly. There are two small pits on the median anterior part of the inferior surface. The presence of an axis intercentrum in both the Opisthocoelia (Sauropoda) and Orthopoda (Predentata) tends to confirm somewhat the contention of Marsh and Hatcher that the Dinosauria is a natural group, and in the examples cited here it should be considered a persistent primitive character which was present in a remote but common ancestor.

The second intercentrum is also present in the typical skeleton of *Camptosaurus nanus*, although not suturely united.

In 1889 Lydekker <sup>b</sup> called attention to the axis of a dinosaur from the Wealden of the Isle of Wight, which had an axil intercentrum attached to it. After comparing it with Marsh's figures of the axis of *Ceratosaurus nasicornis* (holotype, Cat. No. 4735, U.S.N.M.), he considers the general resemblance so close as to indicate the probability of its belonging to the same suborder. He says: "It therefore seems highly likely that it may be referable to the Wealden species of *Megalosaurus* or to a nearly allied form."

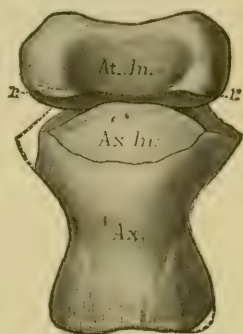


FIG. 12.—VENTRAL VIEW OF ATLAS AND AXIS OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5473, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. at. in., ATLAS INTERCENTRUM; ax., AXIS; ax. in., SECOND INTERCENTRUM; r, FACETS FOR RIB.

<sup>a</sup> C. W. Gilmore, Proc. U. S. Nat. Mus., XXXII, 1907, p. 164.

<sup>b</sup> Quart. Journ. Geol. Soc. London, XLV, 1889, pp. 44, 45.

After a comparison of Lydekker's figures of this specimen (see fig. 13) with the axis of *Camptosaurus*, and noting the many similarities in proportion and position of the processes, together with the presence of an intercentrum on both and the absence of a ventral keel on the centrum of the British specimen, so plainly shown on the axis of

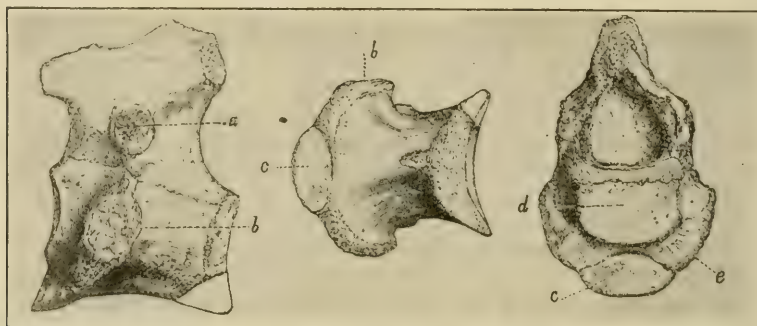


FIG. 13.—LEFT LATERAL, VENTRAL, AND ANTERIOR ASPECTS OF THE AXIS OF AN ORTHOPODUS? DINOSAUR FROM THE WEALDEN OF THE ISLE OF WIGHT NO. R. 1412 BRITISH MUSEUM.  $\frac{1}{2}$  NAT. SIZE. *a*, DIAPOPHYSES; *b*, PARAPOPHYSES; *c*, SECOND INTERCENTRUM; *d*, ARTICULATION FOR ODONTOID PROCESS; *e*, ARTICULATION FOR INTERCENTRUM OF ATLAS. AFTER LYDEKKER.

*Ceratosaurus*. I am quite convinced that this axis pertains to one of the orthopodous dinosaurs rather than to one of the carnivorous forms. It might possibly be referred to *Camptosaurus? valdensis* Lydekker, also from the Wealden of the Isle of Wight.

*Measurements of Specimen, Cat. No. 5473, U.S.N.M.*

	mm.
Greatest length of centrum of axis-----	55
Greatest width anterior extremity-----	59
Greatest width posterior extremity-----	45

*The third cervical.*—The third cervical may be distinguished by its plano-concave (platycœlian) centrum and by the fact that if the planes of the articular surfaces were produced ventrally they would intersect within a foot below the ventral surface of the centrum (see Plate 12). In the succeeding cervicals just the opposite condition is found, that is, the produced planes of their articular ends would meet dorsally. In the articulated cervicals the upward curve of the posterior cervicals changes with the third vertebra to a forward and downward direction, thus giving the neck a graceful sigmoid curve very bird-like in character.

The lateral surface of the centrum is constricted transversely, but flares out posteriorly. The centrum is more regularly rounded, the sides being convex vertically, and it lacks the decided ventral keel found in the cervicals which follow.



There is a well-developed capitular process on the side of the centrum near the anterior end just below the neuro-central suture, and a weak tubercular process near the middle lateral surface of the neural process, posterior and below the level of the prezygapophyses. As in the axis the neural canal is large, being higher than wide, with thin walls.

The postzygapophyses are a pair of slender, divergent processes which extend upward, backward, and outward, their articular faces looking downward and outward. A low, median crest of bone rises posterior to the bases of the prezygapophyses and extends posteriorly to the dividing point of the branches of the zygapophyses.

*Cervicals posterior to the third.*—Marsh has observed: "The cervical vertebræ are all opisthocœlous." In this he was evidently mistaken, as is clearly shown by a study of several individuals which have the complete cervical region preserved. The axis and third cervical are always platycœlian. In most individuals, however, the remaining cervical centra are opisthocœlian, though more strongly so in the posterior than in the anterior cervicals. In Cat. No. 5474, U.S.N.M., the cervical centra, comparatively speaking, remain quite plane throughout the series.

Viewed from the anterior end, the centra are shield-shaped (see 2, fig. 14). Below the neuro-central suture the sides are deeply pinched in, forming lateral depressions which are deeper toward the front, and concave in the longitudinal direction, the articular ends being expanded. Ventrally there is a strong angular keel which widens at either end, more especially the posterior. The ventral surfaces of the ends are roughened by coarse, irregular, longitudinal striae. All of the cervicals have capitular facets on the sides near the anterior end (see *p*, fig. 14). In the anterior region the facets are just below the neuro-central sutures, but in the posterior cervicals, beginning on the fifth in Cat. No. 5473, U.S.N.M., the suture bisects the facets, and thus both the centrum and the neural arch contribute to their formation.

The neurapophyses in all of the cervicals have an extensive attachment to the centrum, spreading out conspicuously at the ends, more especially the anterior, as shown in fig. 14.

Well-developed diapophyses extend outward from the sides of the neural and prezygapophyses, shown at *d*, fig. 14. These gradually increase in length from the third to the ninth. The tubercular facets on their outer extremities look downward and outward. The neural canal remains large throughout the neck, becoming nearly circular in the posterior members. The prezygapophyses are wide apart, their articular faces looking inward and upward. Neural spines are not

<sup>a</sup> Amer. Journ. Sci., XVIII, Dec., 1879, p. 501.



present in the cervicals of *Camptosaurus* unless the weak, median, crest-like ridge found on the posterior elements might be interpreted as such. Dorsally the neural arch consists of a broad, transversely rounded surface which extends backward and upward, the posterior termination giving off the divergent branches of the postzygapophyses. The height of the arch gradually increases posteriorly. Posteriorly just below the junction of the posterior zygapophyses is a pit-like foramen leading forward into the neural process. While this foramen is present in all of the cervicals pertaining to Cat. Nos. 4282 and 5474, U.S.N.M., and in the type of *C. dispar*, No. 1877, Yale Museum, they are entirely lacking in the cervical region of Cat. No. 5473, U.S.N.M.

Fig. 14 (1 and 2) shows the side and front views of the eighth cervical of Cat. No. 4282, U.S.N.M., which may be considered typical

of the vertebrae of the posterior part of the neck.

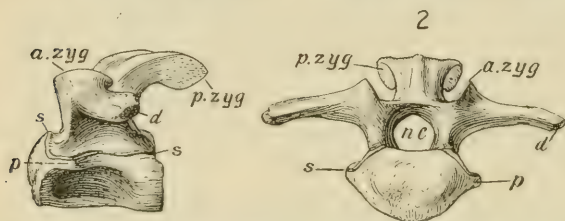


FIG. 14.—(1) EIGHTH CERVICAL VERTEBRA OF CAMPTOSAURUS BROWN. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{3}{4}$  NAT. SIZE, SIDE VIEW; (2) ANTERIOR VIEW OF SAME; a.zyg, PREZYGAPOPHYSES; d, DIAPOPHYSES; nc, NEURAL CANAL; p, PARAPOPHYSES; p.zyg, POSTZYGAPOPHYSES; s, NEURO-CENTRAL SUTURE.

Marsh has given the united length of the nine cervical vertebrae in the holotype of *C. dispar* as 565 mm. The complete cervical region of No. 5473 (see Plate 12) measures

590 mm. and No. 5474, 440 mm. The principal measurements of the cervicals of *Camptosaurus* will be found in table on pages 242 and 243.

*Dorsal vertebrae*.—As mentioned previously, there are 16 dorsals present in the vertebral series of both Cat. Nos. 4282 and 2210, U.S.N.M. It is true, as found, there were interruptions in the series, i. e., not all were found articulated, but after a critical study of the two columns it appears quite probable that 16 will be found to be the correct number. It can not be stated definitely from the known material, but the evidence, at least, points very strongly to the shortening of the presacral series by at least five vertebrae from the number given this animal by Professor Marsh in his restoration of *Camptosaurus dispar*. (See Plate 18.)

*The first dorsal*.—In specimen Cat. No. 4282, U.S.N.M., the first dorsal was, fortunately, found interlocked by its zygapophyses with the last cervical. As mentioned previously, the first dorsal, and cervicals seven, eight, and nine, were taken up in a single block of matrix (see Plate 6, original field numbers 76, 83, 78, and 77), and reached the laboratory occupying their original relative positions. In

consideration of these facts, there can be no question regarding the association of these vertebrae.

That the vertebra now under consideration was a dorsal is shown by the sudden change of the capitular facet from the anterior lateral surface of the centrum on cervical nine, to a point well up on the side of the arch beneath the transversely extended process or diapophysis, and by the great development of the transverse process. The capitular facet is also well developed as compared with the weak facets of the cervicals anterior to it. This facet is slightly cupped and subcircular in outline, being somewhat elongated in the vertical axis.

The length of the centrum of No. 4282 is slightly less than in the preceding vertebra. There is a pronounced cup on the posterior end of the centrum, but anteriorly the end is less convex than in the cervicals preceding, and, as Marsh has pointed out in his description of the cervical region of *Ceratosaurs*, could only be inserted a short distance into the adjoining cup. This distance is accurately marked on the centrum by a narrow, articular border, just posterior and external to the median flattened anterior face. While there are no lateral cavities in this centrum, the sides are deeply excavated, both laterally and inferiorly. The inferior surface presents a narrow, median, longitudinal ridge which widens at either end, more especially the anterior. The surface of this anterior expansion is roughened with longitudinal striæ.

The neural arch is high and incloses a large, circular neural canal. The expanded pedicles of the arch are firmly attached to the centrum by suture. Antero-posteriorly the arch, above its base, is considerably shorter than the centrum, the diapophyses rising from the sides of the arch and extending upward and outward at an angle of  $45^{\circ}$ , as stout, subtriangular processes. The terminations of the diapophyses are lacking in all available specimens. The anterior zygapophyses look decidedly inward and slightly upward, and are elliptical in outline, with the greatest diameter antero-posteriorly. Connecting the anterior zygapophyses at their inferior margins is a thick, rounded shelf of bone which forms the covering of the anterior portion of the neural canal. From the middle, and somewhat posterior to the anterior border of this shelf, a low spinous process is developed, which, in No. 1877, Yale Museum, has a height of 11 mm. Superiorly its termination is angularly rounded antero-posteriorly and slightly thickened transversely. This spine is missing in all of the other specimens studied. Posterior to the anterior zygapophyses and lateral to the median spine are deep depressions in the top of the process. The postzygapophyses are missing on the first dorsal of No. 4282, but are present on that of *C. nanus*, No. 2210. They extend far back beyond the posterior end of the centrum, their articular faces

looking outward and downward. From a posterior view, both vertebræ show, just above the neural canal, a median pit which extends forward and downward into the arch.

*The second dorsal.*—This vertebra differs from the preceding chiefly by the development of a higher spinous process, more robust transverse processes, greater length of centrum, and more elevated position of the capitular facets on the lateral surface of the neurapophyses. The distal extremity of the centrum is not so deeply cupped as in the preceding vertebra, and the anterior extremity is nearly plane, being only slightly concave dorso-ventrally. In median cross section the centrum would be wedge-shaped. The subcircular neural canal is more reduced, and the tubercular rib facet looks downward and forward.

*The third dorsal.*—The third dorsal (see fig. 15) may be distinguished from the second by the increased size of the tubercular and

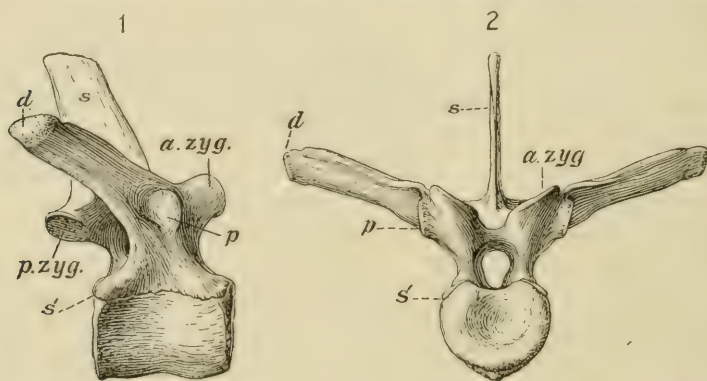


FIG. 15.—(1) THIRD DORSAL VERTEBRA OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. NO. 4282. U.S.N.M.;  $\frac{1}{4}$  NAT. SIZE, SIDE VIEW; (2) ANTERIOR VIEW OF SAME; *a. zyg.*, PREZYGAPOPHYSES; *d*, DIAPOPHYSES; *p*, PARAPOPHYSES; *p. zyg.*, POSTZYGAPOPHYSES; *s*, NEURAL SPINE; *s'*, NEURO-CENTRAL SUTURE.

capitular facets, and the more elevated position of the latter. Also by the more rounded ventral surface of the centrum, which slightly exceeds the second in length.

*Dorsals four to fourteen.*—The succeeding vertebræ are so similar in most respects that they may best be described together. The centra, allowing for distortion by crushing, gradually increase in length from the first to the twelfth, which is the longest of the series in No. 4282. They have their articular extremities concave, more especially on the posterior end, but to a less degree than in those vertebræ anterior. The depressions so marked in the sides of the cervical and anterior dorsal regions below the neuro-central suture, decrease in approaching the trunk, and from the fourth dorsal to the loins the sides are approximately flat vertically, though concave longitudinally, caused by the expansion of the ends of the centra. There is also a diminished angularity of the keel so that the vertebræ of the mid-



dorsal region have rounded ventral surfaces. Posteriorly the centra gradually increase in bulk.

The elevated neural processes of the anterior dorsal region become lower posteriorly, while the low, thin, plate-like neural spines gradually increase in height, with thickened terminal extremities that reach their maximum development in the sacral region.

The transverse processes, stout and relatively long in the anterior dorsal region, have a capitular facet on the fourth dorsal, well up under their front edges, where they spring from the neural arch, and tubercular facets on their outward extremities (see *d* and *p*, fig. 15). The capitular facet withdrawn from the centrum on the first dorsal reaches the anterior border of the diapophysis in the fourth. Posteriorly the capitular facet gradually moves outward on the anterior

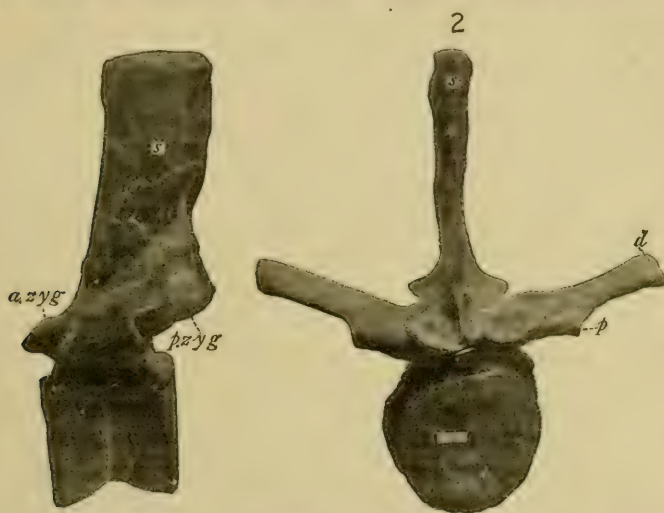


FIG. 16.—(1) THIRTEENTH DORSAL VERTEBRA OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{3}{4}$  NAT. SIZE, SIDE VIEW; (2) ANTERIOR VIEW OF SAME; *a. zyg*, PREZYGAPOPHYSES; *d*, DIAPOPHYSIS; *p*, PARAPOPHYSIS; *p. zyg*, POSTZYGAPOPHYSIS; *s*, NEURAL SPINE. FROM A PHOTOGRAPH.

face of the transverse. Judging from the size of the capitular facet and the capitulum of the rib preserved in place, the seventh dorsal supports the heaviest rib of the series in No. 4282. The transverse processes are directed backward and somewhat upward from the horizontal as they leave the neural arches, and from the mid-dorsal region posteriorly they become more slender and somewhat shorter, with a decrease in size of the tubercular and capitular facets (see fig. 16, *d* and *p*). The diapophyses of the dorsals are supported by heavy buttresses or lamina which rise obliquely forward to their under surfaces from the lower and back part of the neurapophyses. They form the outer boundary of deep, three-sided hollows, as shown in fig. 15. These cavities gradually grow shallower from front to back. The posterior zygapophyses overhang the end of the centrum,



this character being especially pronounced in the posterior dorsal region (see fig. 16). The neural canal remains about the same size from the fourth to the fourteenth.

*The fifteenth dorsal.*—This vertebra may be at once distinguished by its short centrum (see dorsal No. 15, table of measurements, page 243), which in No. 4282 is cylindrical in outline, with a weak ventral keel. The articular ends are concave, more especially the posterior. Antero-posteriorly it is the shortest of the dorsal series. The transverse process is short, wide, and directed outward at right angles to the neural process. It has weak tubercular and capitular rib-facets, which show that it carried a double-headed rib.

*The sixteenth dorsal or sacro-dorsal.*—The last dorsal centrum (sacro-dorsal) is longer and heavier than the one preceding and is the most robust of the vertebral series of No. 4282 (see *sd*, fig. 17). The two articular extremities are slightly concave, the posterior having a rough, rugose surface. Antero-posteriorly the sides are deeply concave, the inferior surface being pinched together, forming a short, pronounced median keel which expands transversely at either end. This vertebra in No. 1877*a*, paratype of *C. dispar* (Yale University Museum), is regularly rounded in this aspect and without ventral keel. On the supero-posterior angles are roughened, obliquely placed surfaces which give partial support to the first sacral ribs. The neuro-central suture is relatively shorter than in the preceding dorsals, a groove for the exit of a nerve limiting its extent posteriorly. The arch is higher than those immediately in front, and supports a weak diapophysis without parapophysial facet, indicating the presence of a single-headed rib which may have articulated with a small articular area on the internal side of the preacetabular process of the ilium. In No. 4282, the outer extremity of this process is missing, but it is plainly shown in the typical specimens of *C. dispar* and *C. nanus*, Plate 13 and fig. 39. As shown in fig. 17, the prezygapophyses are large and look almost directly upward. The spinous process is missing on this vertebra of No. 4282, but is present in No. 1877*a*, Yale Museum (see Plate 13). It is shown as a rectangular plate-like spine rising high above the diapophysis. The superior termination is thickened transversely, more especially on the anterior part of this border, which is heavier than the spine that follows, and, in this species (*C. dispar*), probably marks the maximum development of the spinous processes. The greatest height of this vertebra, taken at the center of the centrum, is 330 mm. The spine has a vertical groove on its posterior border extending nearly to its top. The postzygapophyses overhang considerably the end of the centrum.

*The sacrum.*—In specimen Cat. No. 4282, U.S.N.M., there are seven vertebrae united by a suture in the sacral region. Of this series I have considered as sacral only those vertebrae which support true sacral

ribs. This interpretation excludes the anterior and posterior vertebræ, which may be regarded as sacro-dorsal and sacro-caudal, respectively, thus reducing the number of sacrals to five, as originally determined by Marsh for *C. dispar*.<sup>a</sup> Typically, there are five vertebræ joined by suture, but, as shown in Plate 13, *a*, the anterior one would be considered a dorsal. Hence in *C. dispar* there are only four true sacrals.

Sacrals two and three were found to be firmly coossified (see fig. 17,  $S_2$  and  $S_3$ ), and in this respect quite at variance with Professor Marsh's earlier determinations. In describing the type-specimen of *C. dispar*, he says:

This genus agrees with *Laosaurus* in one important character, namely, the sacral vertebræ are not coossified. That this is not merely a character of immaturity is shown by some of the other vertebræ in the type-specimen, which have their neural arches so completely united to the centra that the suture is nearly or quite obliterated. To this character of the sacral vertebræ, the name of the present genus refers.

While the neural arches of the specimen here considered are attached to the centra throughout the column, the sutures in all instances are plainly discernible. Inasmuch as a second specimen in the National Museum, No. 4753, the holotype of *C. depressus*, has all of the vertebræ of the sacral region firmly coossified, it would appear that what Marsh considered a very important character of the genus, namely, the noncoalescence of the sacral vertebræ, can not be relied on as being a constant character. Moreover, the union of the other centra in the sacrum of specimen No. 4282 were very close and particularly strong, and it was with some difficulty that they were separated for the purpose of study. So firmly are sacrals two and three coossified that in places the suture is entirely obliterated (see fig. 17).

The first sacral may be distinguished by the great transverse expansion of the anterior end of the centrum. Both extremities have roughened sutural surfaces, which unite closely and strongly with the centra both preceding and following. The anterior face is somewhat angularly convex, while the posterior is slightly concave. The inferior surface lacks the decided keel of the last or sacro-dorsal and is more evenly rounded. The neural canal is much expanded, as shown in fig. 17,  $S_1$ . The posterior parts of the pedicles of the neural arch are very thin transversely and comparatively short antero-posteriorly, being to a limited extent borne on the last dorsal. The spinous process, as shown in Plate 13, is very similar to that of the last dorsal described above, but is more anteriorly placed in relation to the centrum. A long diapophysis extends out over the top of the first sacral rib, which, in some individuals, is firmly ankylosed to that bone. In No. 1877*a*, however, the suture remains distinct.

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<sup>a</sup> Amer. Journ. Sci., XLVII, 1894, p. 246.

The centra of sacral two and three are much compressed transversely, as shown in fig. 17,  $S_2$  and  $S_3$ , the third being the smallest of the five. Antero-posteriorly the lateral and ventral surfaces are deeply concave. The inferior surface of sacral two is somewhat pinched together inferiorly, while sacral three is broader and flattened in this aspect.

The fourth sacral was firmly united to the fifth, although the suture is plainly seen. Like those preceding, the sides are concave antero-posteriorly, though the centrum as a whole is more robust than either sacral two or three. Its ventral surface is somewhat flattened transversely, though concave longitudinally. Unfortunately only the centrum of the fifth sacral is preserved in this specimen. It differs but little from the fourth sacral, except that the rib or transverse process is not borne intervertebrally, as are those preceding, but is confined wholly to the anterior half of this centrum, which has a fragment of the articular end still attached, as will be seen by reference to fig. 17. The centrum is also more cylindroid in outline and the floor of the neural canal is much constricted transversely, as in the fourth of *C. (Iguanodon) prestwichii*. The latter observation is also true of the fourth or last sacral (fifth sacral of Marsh) in No. 1877a, Yale Museum, as is plainly shown in fig. 37, 3. A specimen referred to *C. nanus*, in the American Museum of Natural History, which has this region articulated, shows that the ribs or transverse processes of this vertebra reached and gave support to the ilia.

The fourth is the first sacral to show the peculiar peg-and-notch articulation (see fig. 17), considered by Marsh as characteristic of the sacral region of *Camptosaurus*. He says:<sup>a</sup>

The vertebrae of the sacrum, especially the posterior four, are joined to each other by a peculiar peg-and-notch articulation. The floor of the neural canal of each vertebra is extended forward into a pointed process (somewhat like an odontoid process), which fits into a corresponding cavity of the centrum in front. This arrangement, while permitting some motion between the individual vertebrae, helps to hold them in place, thus compensating in a measure for absence of ankylosis.

This articulation may have been present between sacral two and three before ankylosis took place, but this can not now be determined. It is, however, present between sacral three and four, four and five, sacral five and caudal one, and there are also faint indications of the same method of articulation between caudals one and two, and two and three (see *p*, fig. 18).

In this connection it is of interest to know that an examination of the type-specimens of *Laosaurus consors* and *Dryosaurus altus* shows that both specimens exhibit the same peg-and-notch articulation of

<sup>a</sup>Amer. Journ. Sci., XLVII, 1894, p. 246.



the sacral centra, although they have been described as being without it.<sup>a</sup>

The five sacrals give support to five sacral ribs on each side. These ribs, excepting the fifth, are supported intervertebrally by rough sutural areas on their superior junctions, the main support being given by the posterior vertebra of each pair.

The neural processes are either missing or only represented by detached fragments in *C. browni*, but in order to make the description complete, these will be described from the holotype of *C. nanus*, Cat. No. 2210, U.S.N.M., which has the anterior three unusually well preserved (see fig. 39). As in *C. dispar*, there are only four true sacrals in *C. nanus*.

The neural arch in sacral one is somewhat higher than the last dorsal, with a much enlarged neural canal. In sacrals one, two, and three, the arches are contracted antero-posteriorly and expand outwardly into strong buttresses which, with the sutural surface on the centra, give support to the sacral ribs. This antero-posterior contraction of the pedicles leaves vertical, elongate cavities opening into the enlarged intervertebral chamber of the neural cavity for the exit of sacral nerves. The arches are united by heavy and closely fitting zygapophyses. The postzygapophyses are shifted well forward over the center of the centrum.

The neural spines are flattened plates which, as they rise above the arch, gradually expand antero-posteriorly, terminating in an end slightly thickened transversely. The spines remain about the same height throughout, all being inclined somewhat backward. In this specimen the spines are distinct and show no indication of fusion, as is indicated by Marsh's first restoration of this region in *C. dispar*.

The diapophyses of sacral one, in specimen No. 2210, are considerably modified from the thoracic type. They join with an outward development of the pedicle, forming a continuous vertical articular face or buttress, with which the upper portion of the sacral rib articulates. The first is the heaviest of the series, and this sacral rib was undoubtedly the chief support for the ilium. The diapophyses of sacrals two and three are developed in the same manner, although lighter in construction.

In the sacrum of Cat. No. 4282, U.S.N.M., sacral ribs one and two were still in position and completely ankylosed with the vertebrae (see *sr*, fig. 17). These ribs are short, compressed plates with expanded articular ends. Inferiorly the first rib articulates with the centra of the last dorsal and first sacral, more especially the latter. Above, the rib has become coossified with the buttress and diapophysis of sacral one. This broad, vertical plate is directed outward and somewhat backward. Its outer end is expanded antero-posteri-

<sup>a</sup> Amer. Journ. Sci., XLVIII, 1894, pp. 88, 89.



only and coalesces with the similarly expanded end of the second rib, thus inclosing a subcircular sacral foramen ( $f$  and  $f^1$ , fig. 17). If present, the other ribs would probably repeat this arrangement, and there would be a row of at least four of these foramini—possibly five, if the transverse of the first sacro-caudal reaches the interoposterior border of the ilium, which I doubt. The outer coalesced ends of ribs one and two exhibit a wide articular area, looking downward and outward, for articulation with the ilium. Two of these ribs were found with specimen No. 2210, but both were detached, although not far removed from their positions in the sacrum. It would appear from the evidence of these two individuals that in the young they remain distinct, but in the adult become completely fused with the sacrum.

After a study of these processes as represented in *Camptosaurus*, it is at once apparent that they are derived from centers of ossification entirely distinct from those which give origin to the centra or their neuropophyses. Inasmuch as the diapophyses are distinct from the sacral ribs, as shown in some individuals, there appears no good reason why, in this group at least, they should not be considered true ribs, modified to fit the exigencies of their position. The sacrodorsal in *Camptosaurus*, as in *Triceratops*, is considered to be without parapophyses. The parapophyses of the second sacral, however, might be considered the articular area on the pedicle of the arch below the diapophyses, extending down on to the centrum which supports the lower articular portion of the sacral rib. The additional support given this rib by the posterior area of the first sacral centrum I should consider as being homologous with the demi-facets found in the dorsals of certain groups of the mammalia. The fact that a single-headed rib is borne by the last dorsal shows without question that the first sacral rib would, as shown previously, pertain to sacral one.

While Hatcher <sup>a</sup> has shown the probability of the supports for the ilia in the Sauropoda being the coalesced dia- and parapophyses, his arguments do not appear conclusive, and in view of the evidence here presented I am convinced that in *Camptosaurus* at least the existence of true sacral ribs is fully determined.

When the centra are articulated the ventral surface as a whole is slightly arched, its outline being rendered sinuous by the constriction of the middle of the centra and the prominence of their terminal borders. In *Camptosaurus*, as shown by the sacra considered in the previous pages, the sacrum is composed of either four or five vertebrae, which will receive further attention in the present paper when the several species are discussed.

<sup>a</sup> Mem. Carnegie Mus., II, No. 1, Nov., 1903, pp. 21, 22.

*The caudal vertebrae.*—Thirty-three caudal vertebrae were found associated with Cat. No. 4282, U.S.N.M. Their position in the quarry in relation to one another is clearly shown in Plate 6. With the type of *C. nanus* (Cat. No. 2210, U.S.N.M.) were 34 caudals, most of them still connected by the adhering matrix. After careful consideration of the evidence presented by the above series, it is estimated that in *Camptosaurus* there would be at least 44 caudal vertebrae in the complete tail.

As found, there were interruptions (see Plate 6) in the anterior series of No. 4282, but upon assembling the scattered parts it is believed they represent an unbroken string as far back as the sixteenth caudal. Between the sixteenth (quarry number 208) and the distal series (beginning with quarry number 235, see quarry map, Plate 6), it is estimated there are five vertebrae missing.

The above estimate is based not only upon the proportionate ratio of decrease in size necessary to fill the gap, but also upon the caudal series of *C. nanus*, which has this region intact and still connected by matrix. The terminal caudals are unknown, but the last one of the series (estimated to be the thirty-eighth, quarry number 234) has a transverse diameter on the posterior end of 13 mm. It is not likely there was a series of rod-like caudals, as found in some members of the Opisthocoelia,<sup>a</sup> but rather that the tail ended more abruptly like that of *Stegosaurus*, that is, with a pointed terminal caudal, as shown by three specimens in the National Museum.

In No. 4282, U.S.N.M., the first caudal (*sc*, fig. 17), or, as it might be better termed, sacro-caudal, is united to the sacrum by suture, being more securely joined by the peg-and-notch articulation (see fig. 17). It is considerably shortened antero-posteriorly, and, viewed from the end, is cylindroid in outline. A heavy subcircular rib, or transverse (*tr*, fig. 17), is attached by suture to the neural process just above the neuro-central suture. The neural canal is contracted to a small, circular passage having a diameter of 15 mm. On the median ventral surface are two subcircular depressions separated by a median longitudinal ridge or keel. The neural arch is much compressed transversely. The anterior zygapophyses are placed quite close together, their articular faces being nearly vertical, while the posterior are placed more obliquely and slightly overhang the end of the centrum. The spinous process of this vertebra is missing. The second caudal bears the first chevron (see *cf.*, fig. 18). Its centrum has a cupped anterior surface, the whole contour of this end being concave dorso-ventrally. The posterior articulating surface is more rounded, with an oblique ventral surface for the attachment of the chevron. This end is only slightly concave on the

<sup>a</sup> J. W. Holland, Mem. Carnegie Mus., II, 1906, p. 253.

upper median face. The lateral surfaces of the centrum are evenly concave antero-posteriorly. The small, circular neural canal extends down somewhat obliquely from front to back, a peculiarity present

in a few of the succeeding vertebræ, and appears to indicate a rapid dropping of the tail as it leaves the sacrum. The neural arch is low and firmly attached to the centrum by broadly expanded pedicles. The transverse processes spring from the sides of the neural arch just above the neuro-central suture (see *s'*, fig. 18), extending out at right angles to the centrum on a level with the neural canal, not so high above it as shown in Marsh's restoration of *C. dispar* (see Plate 18).

It has also been determined from these specimens that Marsh's representation of this region on Plate 56, "Dinosaurs of North America," is in error in the following respects: The neural arches are too high; the spinous processes are too straight and do not decrease in height rapidly enough after leaving the sacrum; their bases should show the antero-expansion of the base of the spine, and their tops should be directed at more of an angle posteriorly. The spinous process of the second caudal rises as a high, thin, backwardly directed blade of bone (see *s*, fig. 18), ter-

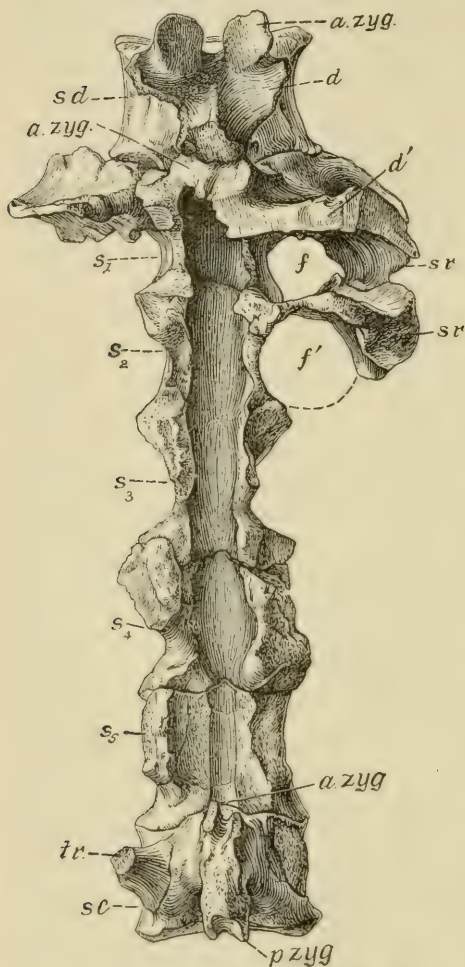


FIG. 17.—SACRUM OF CAMPTOSAURUS BROWN. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{1}{4}$  NAT. SIZE: SEEN FROM ABOVE. *a. zyg.*, PREZYGAPOPHYSES; *d*, DIAPOPHYSIS OF 16TH OR SACRODORSAL; *d'*, DIAPOPHYSIS OF SACRAL ONE; *f*, *f'*, FORAMINA BETWEEN THE SACRAL RIBS; *p. zyg.*, POSTZYGAPOPHYSES; *s*<sub>1</sub>, *s*<sub>2</sub>, *s*<sub>3</sub>, *s*<sub>4</sub>, *s*<sub>5</sub>, SACRAL VERTEBRÆ ONE TO FIVE, RESPECTIVELY; *sc*, SACRO-CAUDAL; *sd*, SACRO-DORSAL; *sr*, SACRAL RIBS; *tr*, TRANSVERSE PROCESS OF SACRO-CAUDAL.

minated by a slightly thickened end, which is gently rounded antero-posteriorly. There is a prominent widening of the base of the spine by the development on the anterior margin of a thin septum of bone which subsides rapidly above. This anterior development of the



base of the spine becomes less and less pronounced, only a vestige remaining on the thirteenth caudal.

From the third to the tenth the centra gradually increase in length, the articular ends also undergo modifications from the vertically elongated type anteriorly to the compressed medially, and to the cylindroid of the posterior half, both ends of nearly all of the centra being slightly concave.

Flattened transverse processes are present on the first twelve vertebrae counting from the sacrum. The third is believed to bear the longest transverse, behind which they gradually shorten until, on the thirteenth, there remains only an inconspicuous tubercle. The sup-

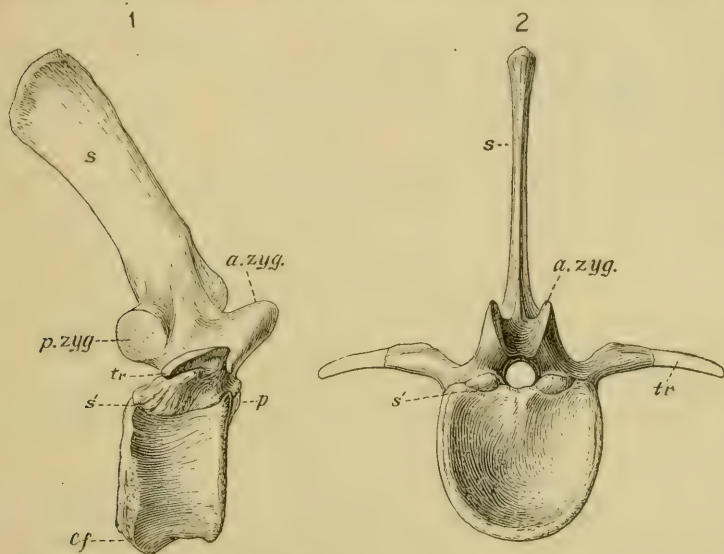


FIG. 18.—(1) SECOND CAUDAL VERTEBRA OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{1}{4}$  NAT. SIZE; SIDE VIEW. (2) ANTERIOR VIEW OF SAME; *a. zyg.*, PREZYGAPOPHYSES; *cf*, FACET FOR FIRST CHEVRON; *p*, RUDIMENTARY PEG-LIKE PROJECTION; *p. zyg.*, POSTZYGAPOPHYSIS; *s*, NEURAL SPINE; *s'*, NEURO-CENTRAL SUTURE; *tr*, TRANSVERSE PROCESS.

pression of the transverse process is soon followed by the disappearance of the neuro-central suture, which becomes very indistinct. The point of attachment of the transverse processes gradually moves backward from the anterior lateral surface in the proximal caudals to a postero-lateral position in those more distal. As Hatcher<sup>a</sup> has pointed out in *Haplocanthosaurus*, so in *Camptosaurus* the transverse processes are derived from centers of ossification distinct from those which gave origin to either the centra or their spinous processes. This fact may be considered by some as proof that these are not transverse processes but perhaps might be considered caudal ribs

<sup>a</sup> Mem. Carnegie Mus., II, 1903, p. 22.



homologous with those of the sacral region. The compressed, blade-like spines of the anterior caudals decrease rapidly in both height and width antero-posteriorly to a compressed, rod-like spine on the eighth.

The spines gradually reduce in size posteriorly, at the same time becoming more and more depressed until in the smallest and most posterior they are nearly parallel with the longer axes of the centra (see fig. 19). As found in No. 4282, they persist almost to the end of the tail as small bony rods with compressed ends, without expansion, which extend well back over the succeeding vertebra.

The anterior zygapophyses gradually lengthen posteriorly until, in the distal caudals, as shown in fig. 19, they consist of two slender

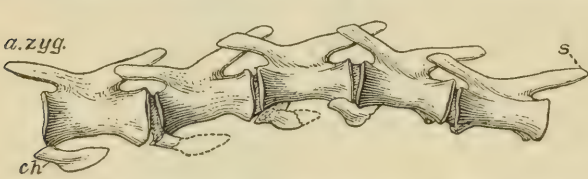


FIG. 19.—POSTERIOR CAUDAL VERTEBRÆ WITH CHEVRONS (30TH TO 34TH, INCLUSIVE), CAMPTOSAURUS BROWN. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE; SIDE VIEW; *a. zyg.* PREZYGAPOPHYSIS; *ch*, CHEVRON; *s*, NEURAL SPINE.

finger-like processes which extend forward and lap along the base of the neural spine of the preceding vertebra. The posterior zygapophyses of

the anterior caudals slightly overhang the ends of the centra but gradually come to occupy a higher position on the spine, and with the increased slant of the latter, they overhang considerably. The zygapophyses also grow smaller until just back of the middle caudal region there is no well defined articular area, the zygapophyses simply clasping the base of the spine, as mentioned above.

The anterior vertebrae have oblique facets on both ends of the centra, but in the distal region there remain only weak facets on the ventral posterior ends. The anterior chevron facets are the first to disappear.

Principal measurements of vertebrae.

Vertebrae.	Greatest length of centra.			Greatest transverse diameter, posterior ends.			Remarks.
	U. S. N. M. No. 4282.	Yale Museum No. 1877. <sup>a</sup>	U. S. N. M. No. 2210. <sup>b</sup>	U. S. N. M. No. 4282.	Yale Museum No. 1877. <sup>c</sup>	U. S. N. M. No. 2210.	
	mm.	mm.	mm.	mm.	mm.	mm.	
Atlas .....		24			56		
Axis .....		53	20		53	18	Anterior end No. 2210 =22 mm., transverse diameter.
3.....	70	61	23	<i>a</i> 40	46	19	
4.....	70	53	24		45	<i>a</i> 21	
5.....		59	26		47	22	
6.....		50	26		56	22	
7.....	67	52	26	70	54	23	Greatest height (with spine) of No. 4282, taken at center, 93 mm.
8.....	77	62	25	66	58	24	Greatest height (with spine) of No. 4282, taken at center, 91 mm.

<sup>a</sup> No. 1877=holotype *C. dispar*. <sup>c</sup> No. 1877 *a*=paratype *C. dispar*.  
<sup>b</sup> No. 2210=holotype *C. nanus*. <sup>d</sup> Estimated measurements from mutilated specimens.

## Principal measurements of vertebrae—Continued.

Vertebrae.	Greatest length of centra.			Greatest transverse diameter, posterior ends.			Remarks.
	U. S. N. M. No. 4282.	Yale Museum No. 1877.	U. S. N. M. No. 2210.	U. S. N. M. No. 4282.	Yale Museum No. 1877.	U. S. N. M. No. 2210.	
9.....	mm. 70	mm. 61	mm. 26	mm. 68	mm. 64	a 23	Greatest height (with spine) of No. 4282, taken at center, 95 mm.
Dorsal 1.....	63	61	24	60	a 61	22	
2.....	70		25	62		20	
3.....	75		26	66		21	Greatest height (with spine) of No. 4282, taken at center, 183 mm.
4.....	72		25	60		22	
5.....	74		28	62		22	
6.....	75		30	66		23	
7.....	75		29	70		24	
8.....	75		29	69			
9.....	70		31	70		27	
10.....	70		30	70		a 28	
11.....	77		30	78		a 32	
12.....	80		31	80		33	
13.....	75		31	90		a 35	Greatest height (with spine) of No. 4282, taken at center, 260 mm.
14.....	65	Yale Museum.	27	94		36	
15.....	57	No. 1877a	30	107		47	
16.....	66	86	32	118	125	48	Greatest height (with spine) of No. 1877a, taken at center, 330 mm.
Sacral 1.....	73	85	30	118	119		Greatest height (with spine) of No. 1877a, taken at center, 328 mm.
2.....	75	82	31	a 77	100	34	
3.....	75	76	30	90	90	a 33	
4.....	70	80	30	a 95	110		
5.....	70			101			
Caudals:							
1.....	62		28	101		a 37	
2.....	60		25	a 85		36	Greatest height (with spine) of No. 4282, taken at center, 270 mm.
3.....	57		26	83		34	
4.....	59		27	77		32	
5.....	60		25	76		29	
6.....	60		26	a 70		28	
7.....	60		25	82		26	
8.....	61		26	67		26	
9.....	71		25	66		25	
10.....	70		25	51		25	
11.....	69		a 24	54		24	
12.....	66		26	54		23	
13.....	64		26	54		24	
14.....	69		27	60		24	
15.....	71		26	58		24	
16.....	73		26	a 58			
17.....			26			22	
18.....			26			22	
19.....			25			22	
20.....			24			24	
21.....			24			a 23	
22.....	62		23	a 48		22	
23.....	60		21	48		22	Greatest height (with spine) of No. 4282, taken at center, 68 mm.
24.....	60		21			a 21	
25.....	56		21			20	
26.....	55			40			
27.....	55						
28.....	54			37			
29.....	52						

a Estimated measurements from mutilated specimens.

*Principal measurements of vertebrae—Continued.*

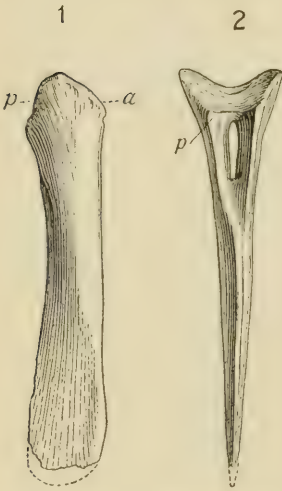
Vertebrae.	Greatest length of centra.			Greatest transverse diameter, posterior ends.			Remarks.
	U. S. N. M. No. 4282.	Yale Mu- seum No. 1877.	U. S. N. M. No. 2210.	U. S. N. M. No. 4282.	Yale Mu- seum No. 1877.	U. S. N. M. No. 2210.	
Caudals— Continued.	mm.	mm.	mm.	mm.	mm.	mm.	
30.....	50	.....	.....	.....	.....	.....	
31.....	49	.....	.....	.....	.....	.....	
32.....	47	.....	.....	.....	.....	.....	
33.....	47	.....	.....	22	.....	.....	
34.....	43	.....	.....	22	.....	.....	
35.....	41	.....	.....	20	.....	.....	
36.....	39	.....	.....	17	.....	.....	
							Greatest height (with spine) of No. 4282, taken at center, 32 mm.
37.....	39	.....	.....	15	.....	.....	
38.....	38	.....	.....	13	.....	.....	

## THE CHEVRONS.

Chevrons from the anterior, middle, and posterior parts of the tail were found in position with the caudals of Cat. No. 4282, U.S.N.M.

The anterior chevrons are longer than the spinous processes and are reduced more slowly posteriorly. They are Y-shaped, with expanded articular ends, the surfaces of the opposite sides being bridged across. Viewed laterally (see 1, fig. 20), this end is wedge-shaped, the posterior facet being the larger. The chevrons articulate intervertebrally with beveled articular surfaces on the ends of the centra. The opening between the branches, as compared with the chevrons of other members of the Dinosauria, is much constricted both transversely and longitudinally. The free end is expanded and flattened. The shaft is straight, not curved backward, as in many reptiles, in this respect similar to the anterior chevrons found in the trachodonts. With the exception of being smaller and having the articular end about evenly divided between the anterior and posterior facets, and the lower part of the shaft curved backward, the median chevrons are very similar to those described above.

FIG. 20.—(1) ANTERIOR CHEVRON OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5818, U.S.N.M.;  $\frac{1}{3}$  NAT. SIZE; SIDE VIEW; (2) POSTERIOR VIEW OF SAME; *a*, ANTERIOR; *p*, POSTERIOR.



Those of the more posterior region, however, are considerably altered from the above types, as will be seen by reference to fig 19.

The articular ends of the opposite sides are separate and when in position unite more especially with the anterior than with the posterior vertebra. The opening between the branches is proportionately more elongated, and the free end is thin and expanded into a broad, knife-like end. The chevron found articulated between quarry numbers 220 and 221 of the distal series is 52 mm. in length. This would be the twenty-fourth of the series counting from the sacrum. The twenty-eighth is 45 mm. (see *ch*, fig. 19) in length, and the thirty-first is only 25 mm. The free end is rounded from the lower margin of the opening up to the dorsal border, as a thin, sharp keel, well shown in *ch*, fig. 19. In a rudimentary form they appear to have persisted as far back as the thirty-sixth caudal, as indicated by imperfectly developed chevron facets on the centra.

#### THE RIBS.

In *Camptosaurus* there are present cervical, dorsal, sacral, and caudal (?) ribs. Excepting the atlas, all of the cervical vertebrae, as shown by the distinct tubercular and capitulum facets, bear double-headed ribs.

*Cervical ribs*.—The capitulum is in all cases carried on the longer of the two anterior branches. This branch, which is comparatively short on the anterior cervical ribs, gradually lengthens posteriorly, being considerably produced on the eighth and ninth of the series (see *c*, fig. 21). The posterior branch terminates as a somewhat rounded,



FIG. 21.—EIGHTH CERVICAL RIB OF LEFT SIDE CAMPTOSAURUS BROWN. HOLOTYPE. CAT. NO. 4282. U.S.N.M.;  $\frac{1}{4}$  NAT. SIZE; SIDE VIEW; *c*, CAPITULUM; *t*, TUBERCULUM.

pointed end. As shown by the single facets on the posterior ventral surface of the intercentrum of the atlas (see *v*, fig. 12), it appears to have carried a single-headed rib, as in the crocodile.

Anterior cervical ribs pertaining to Cat. No. 5473, U.S.N.M., show the point where the two anterior branches unite as a broad rounded base with very short, pointed posterior branch (see Plate 12). In Cat. No. 4282, U.S.N.M., the ribs of the eighth and ninth cervicals were found articulated and in a fairly good state of preservation. These are thin, flattened bones, without pronounced anterior indentation. The capitular process is moderately long, with convex articular end, while the tubercular process is short, heavy, and has a concave articular end. When articulated their posterior extremities are directed backward, outward, and downward, somewhat below the horizontal.

*Dorsal ribs*.—With the exception of the last dorsal, or, better, sacro-dorsal, all of the other dorsal vertebrae bear double-headed ribs. The ribs of the anterior portion of the thoracic cavity are considerably curved, especially near their upper extremities. The



capitulum is borne on a heavy, rounded process, being well separated from the weaker step-like tuberculum developed on the supero-posterior border. Posteriorly, however, the capitular facets on the vertebrae gradually shift their position nearer to the tubercular facet, and thus the distance between the capitulum and tuberculum of the rib is gradually lessened. Fragmentary ribs found articulated with the dorsals of Cat. No. 4282, U.S.N.M., shows that the seventh (counting from the last cervical) bears the heaviest rib of the series. The posterior ribs are more slender, straighter, and shorter than those anterior.

The sacro-dorsal mentioned above must have borne a short, single-headed rib, as indicated by the single capitular facet on the other extremity of the weak transverse process (see fig. 39 and *a*, Plate 13), but there is no indication of ankylosis of the rib with the end of the transverse, as Hulke<sup>a</sup> has found in this region of *Hypsilophodon foxii*.

The sacral ribs will be found described in connection with the sacrum on page 237, and the caudal ribs, or transverse processes, with the caudal vertebrae.

#### OSSIFIED TENDONS.

In the matrix surrounding some of the vertebrae of No. 4282 there are preserved a number of flattened, rod-like ossified tendons. In this individual they were found as far forward as the eleventh dorsal, and in the type of *C. nanus*, on the eighth. These ossifications are also present in the sacral region, and they undoubtedly occurred along the spinous processes of the anterior caudals, although from the condition of the available material this point can not be determined. The ends are much flattened and divided into a number of ray-like points. They do not appear to have had any such development as found in either *Trachodon* (*Claosaurus*) or *Triceratops*. These ossifications are shown at *ot* in fig. 39.

In a paper on *Hypsilophodon*,<sup>b</sup> Baron Nopcea calls attention to the presence of ossified tendons along the backbone of that animal, and he also shows that these ossifications are present in all of the British predentate reptiles, with the exception of *Scelidosaurus*. In the American members of this group they were first observed by Marsh<sup>c</sup> in *Trachodon* (*Claosaurus*), and later in members of the *Ceratopsia* by Hatcher.<sup>d</sup>

The arrangement of the tendons along the posterior dorsal vertebrae and over the sacrum is well represented in Plate 19, where they are shown as found in the matrix. Their arrangement approximates the conditions present in *Iguanodon bernissartensis* as figured by Dollo.<sup>e</sup>

<sup>a</sup> Phil. Trans. Roy. Soc. London, CLXXIII, 1882, p. 1047.

<sup>b</sup> Geological Magazine, May, 1905, pp. 203-208.

<sup>c</sup> Amer. Journ. Sci., XLIV, Oct. 1892, p. 345.

<sup>d</sup> Mon. U. S. Geol. Surv., XLIX, 1907, p. 51, fig. 48.

<sup>e</sup> Bull. Bruxelles Mus. Roy. d'Hist. Nat. de Belgique, II, 1883, pl. v.

## THE SHOULDER GIRDLE.

The scapula and coracoid are the only elements preserved in the pectoral arch. Nothing representing either a clavicle or a sternal has yet been found, although it appears quite probable, as will be shown later, that such may have been present, notwithstanding Marsh's statement that the sternum in *Camptosaurus* was unossified.

*The scapula.*—The scapula is a moderately long bone, and when not flattened by crushing has a decided bow in the shaft which conforms closely with the outward curve of the body cavity (see fig. 22), and which throws the articulated coracoid well in under the chest. Just above the heavy, expanded articular end the shaft contracts rapidly, but again gradually expands antero-posteriorly toward the upper end. The backward extension of the blade being the greater, the median external portion of the shaft is gently rounded transversely, while the thin expanded upper extremity of the blade is quite flat. The upper end terminates as a slightly thickened rounded border. The anterior border is sinuous and has a sharp edge, while the posterior is rounded except in its upper third, which is comparatively thin and sharp. The internal surface is smooth and flattened, with a decided bow from end to end, as mentioned above. The articular end being expanded both vertically and transversely, is heavy and massive. A prominent ridge is developed on the lower outer surface, which contributes to the formation of the posterior lip of the glenoid fossa (see *g*, fig. 23). On the anterior margin, above the articulation for the coracoid, is a strong protuberance with a well-defined triangular facet, adapted to the support of a clavicle, if such a bone were present. This feature is clearly shown in the right scapula of No. 5473, U.S.N.M., and is also seen in other scapulae in the same collection. A somewhat similar protuberance is noticed on the scapulae of the larger trachodonts. A short but prominent ridge rises on the external face of the projection just described, but gradually subsides upon reaching the flattened surface of the shaft. The articular end presents a thickened, roughened, deeply pitted sutural articulation for the coracoid, with which it has never yet been found firmly coossified. Inferiorly and posterior to this border is a smooth, concave articular surface which, with a similar surface on the coracoid, forms the glenoid fossa.



FIG. 22.—POSTERIOR VIEW OF ARTICULATED SCAPULA AND CORACOID OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5473, U.S.N.M.;  $\frac{1}{3}$  NAT. SIZE; c, CORACOID; gl, GLENOID CAVITY; s, SCAPULA. FROM A PHOTOGRAPH.

On the median internal surface near the border of the articular end for the coracoid is a narrow, longitudinal groove which passes outward diagonally to meet the foraminal notch in the coracoid.



FIG. 23.—LEFT SCAPULA OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{1}{3}$  NAT. SIZE; VIEWED EXTERNALLY; c, SURFACE FOR CORACOID; g, GLENOID CAVITY. FROM A PHOTOGRAPH.

This groove is present on all of the scapulae studied, and, so far as I am aware, is only found in the Dinosauria among the members of the Camptosauridae and the Laosauridae.

*Measurements of Specimen Cat. No. 4282, U.S.N.M.*

	mm.
Greatest length of left scapula and coracoid.....	595
Greatest length of scapula.....	482
Greatest breadth of scapula.....	175
Least breadth of scapula.....	63
Greatest expanse of glenoid cavity.....	83

*The coracoid.*—The coracoid is a small subrectangular bone, with the anterior and inferior borders turned inward, forming a moderately deep concave internal surface both antero-posteriorly and vertically. Externally the surface is convex in both directions. There is a broad notch on the inferior border. Anterior to this notch the border is thickened on the antero-infero angle, the surface being roughened, more especially the internal, and is thus indicative of the presence of cartilaginous attachment of sternal elements. The border posterior to the notch is especially thickened and represents the coracoid component of the glenoid fossa (see c, fig. 24). The inferior smooth articular part of the posterior border is separated from the rugose surface for union with the scapula by a deep, foraminal notch, which on some individuals is nearly closed. This notch passes through

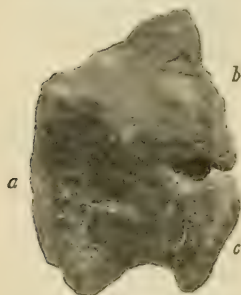


FIG. 24.—LEFT CORACOID OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. NO. 4282, U.S.N.M.;  $\frac{1}{3}$  NAT. SIZE. EXTERNAL VIEW. a, ANTERIOR BORDER; b, BORDER FOR ARTICULATION WITH SCAPULA; c, BORDER OF GLENOID CAVITY. FROM A PHOTOGRAPH.

diagonally, emerging on the postero-internal border, as in *Iguanodon*. In none of the specimens examined did it exist as a well-defined



foramen, as found in other members of the Dinosauria and as indicated by Marsh in his illustrations of this element. The superior border presents a thin, sharp edge, while the anterior is more rounded and roughened, with a thickened portion at the antero-superior angle.

*Measurements of Specimen Cat. No. 4282, U.S.N.M.*

Greatest length of left coracoid-----	mm. 115
Greatest width of left coracoid-----	156

THE FORE LIMB.

*The humerus.*—The humerus is comparatively short, being somewhat expanded at both extremities, more especially the proximal.



FIG. 25.—LEFT HUMERUS OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. No. 4282, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. FRONT VIEW. *d*, DELTOID CREST. FROM A PHOTOGRAPH.

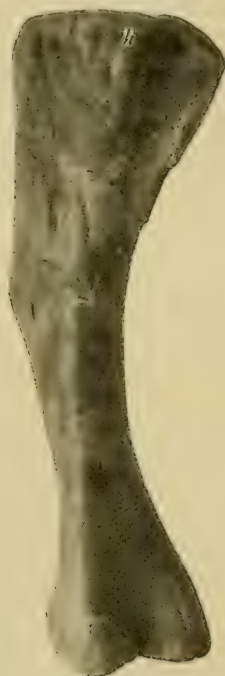


FIG. 26.—LEFT HUMERUS OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. No. 4282, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. BACK VIEW. *h*, HEAD. FROM A PHOTOGRAPH.

The head is situated in about the middle of the proximal end and is produced considerably backward beyond the posterior border of the shaft (see *h*, fig. 26). It has a smooth, subspherical, articular surface from which a ridge-like swelling passes down into the posterior surface of the shaft. There is a heavy radial crest developed on the antero-external border just above the middle of the shaft which renders the anterior aspect of the surface concave. The crest (see *d*, fig. 25) appears to occupy a lower position on the shaft than it does



on the humerus of *Iguanodon*. The shaft is somewhat twisted and planes passed through the longer axes of the articular ends would cut one another at a slight angle. The outer surface of the radial crest is roughened for muscular insertion. Below the crest the shaft is constricted and is subcircular in cross section. The internal border is regularly curved from end to end, while the external is angularly convex. The radial and ulnar condyles are well defined and posteriorly are separated by a broad, shallow depression which passes somewhat up the shaft of the bone. There is also a shallower depression between them on the distal anterior surface of the bone. The articular ends of the humerus are quite rugose in the individual here described.

*Measurements of Specimen, Cat. No. 4282, U.S.N.M.*

Greatest length of left humerus-----	mm. 360
Greatest width proximal end-----	116
Greatest width dorsal end-----	82

*The ulna.*—The ulna is heavy above and but little expanded on the distal end. Its



FIG. 27.—RIGHT RADIUS, ULNA, AND MANUS OF CAMP-TOSAUR'S BROWN. HOLOTYPE. CAT. NO. 4282, U.S.N.M.; ABOUT  $\frac{1}{2}$  NAT. SIZE. FRONT VIEW. SHOWS POSITION OF ELEMENTS AS FOUND IN THE QUARRY. *i*, INTERMEDIUM; *ra*, RADIUS; *u*, ULNARE; *ul*, ULNA. FROM A PHOTOGRAPH.

length slightly exceeds that of the radius, but is shorter than the humerus, differing in the latter particular from *Trachodon*, in which the ulna exceeds the humerus in length. There is the beginning of a massive olacrenon (see fig. 41), but it extends but little above the articular surface for the humerus. Viewed proximally the end is subtriangular in outline. The middle of the shaft in cross section is elliptical. The distal end is somewhat expanded (see *ul*, fig. 27), the greatest diameter be-

ing transverse. The lower internal surface is slightly roughened and flattened for contact with the grooved external surface of the distal

part of the radius (see fig. 41). The articular ends of this bone are smoother than the corresponding parts of the humerus.

*Measurements of Specimen, Cat. No. 4282, U.S.N.M.*

Greatest length of left ulna.....	mm. 262
Greatest width proximal end of ulna.....	75
Greatest width distal end of ulna.....	62

*Radius.*—The radius is more slender and somewhat shorter than the ulna. It is slightly expanded at the extremities, more especially the proximal end (see *ra*, fig. 27). In cross section the shaft is sub-circular and continues so for most of its length. On the distal external surface of the bone is a longitudinal groove which receives the roughened border of the distal end of the ulna when articulated. Viewed from the distal end the extremity is heavy and roughly sub-crescentic in outline, with an oblique end, the surface of which looks downward and outward and fits closely to the reverse bevel of the radiale. This is clearly shown in fig. 27, which represents the forearm and carpus of the right fore limb of *C. browni*, Cat. No. 4282, U.S.N.M.

*Measurements of Specimen, Cat. No. 4282, U.S.N.M.*

Greatest length of left radius.....	mm. 232
Greatest width of proximal end.....	58
Greatest width of distal end.....	41

THE FORE FOOT.

In *Camptosaurus* there are five digits in the manus, supported by eight carpalia. The carpus has a simple arrangement, that is, a proximal row of three bones—the radiale, intermedium, and ulnare—and a distal row of five. The number of phalanges, beginning with the first digit or pollex, as correctly determined by Marsh, is 2, 3, 3, 3, 2.

The detailed description to follow is based upon a fore foot of *Camptosaurus dispar*, Cat. No. 4277, U.S.N.M., from quarry 13, near Como, Albany County, Wyoming. The foot is complete with the exception of phalanges one and two of Digit I, and two and three of Digit IV. The missing parts, with the exception of the ungual of Digit I, which is unknown, will be described from other feet in the National Museum. This foot was found articulated in the field and was so received in the laboratory, and on that account there can be no question regarding the relative position of its elements. The form and proportions of the various bones of the manus are well shown in fig. 28.

*The carpus.*—In the carpus of the typical specimen of *Camptosaurus dispar*, No. 1877, Yale Museum, Marsh recognized nine carpal bones, but I am unable to detect more than eight. Specimens in the

National Museum also show but eight. It appears that the number will vary in fully adult individuals, due to the fusion of the smaller with the larger members.

The proximal row forms two distinct concave surfaces for articulation with the distal ends of the radius and ulna. These articulating surfaces are clearly defined, as in many of the fore limbs of the mammalia, an unusual condition as is well known to all who have attempted to articulate the limb and foot elements of most members of the Dinosauria. The contour of these opposing articular ends is distinctly shown in fig. 27, which represents the right fore foot of *C. browni*, and is reproduced from a photograph of the specimen as it was found in the quarry.

The *radiale* (*r*) is an irregularly shaped, block-like bone, the most robust element of the carpus. Its proximal end forms the chief support for the radius, the distal end articulates with Metacarpal I and carpalia one, two, and three, and externally with the internal border of the intermedium, with which it is often coossified (see fig. 27). The union with Metacarpal I is at an angle of nearly  $45^\circ$  to the main axis of the foot, and in all of the feet studied, where these elements were preserved, they were found to be firmly ankylosed, particularly along the anterior surfaces, as will be seen in fig. 28. This digit was thereby rendered immovable,

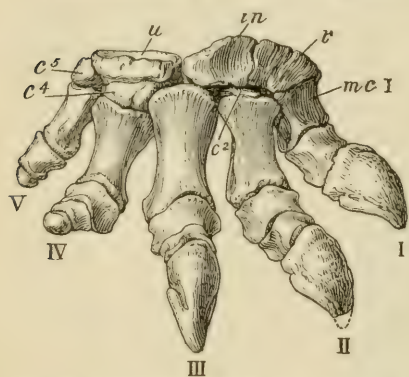


FIG. 28.—RIGHT FORE FOOT, CAMPTOSAURUS DISPAR MARSH. CAT. NO. 4277, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. SEEN FROM THE FRONT. *c*<sup>2</sup>, CARPAL TWO; *c*<sup>4</sup>, CARPAL FOUR; *c*<sup>5</sup>, CARPAL FIVE; *in*, INTERMEDIUM; *mc* I, METACARPAL I; *r*, RADIALE; *u*, ULNARE; I TO V, DIGITS ONE TO FIVE. UNGUAL OF FIRST DIGIT RESTORED.

which is suggestive of the "spike-like" digit of the allied *Iguanodon*.

The *intermedium* (*in*) viewed from the front is subtriangular in outline, the apex pointing toward the ulna (see *in*, fig. 28.) Its dorsal surface articulates with both the radius and ulna, but more especially with the latter; ventrally it is supported by Metacarpal III, and a small, irregularly shaped element on the posterior internal part of this end which probably represents *C*<sub>3</sub>. Although apparently in position in this foot, in the right fore foot of another specimen (Cat. No. 5473, U.S.N.M.), *C*<sub>3</sub> lies more over the proximal end of Metacarpal III, which somewhat confirms its identification. This element, however, is about equally divided between the intermedium and radiale.

The *ulna* (*u*) is a cushion-like bone, its transverse being greater than the antero-posterior diameter (see *u*, figs. 27 and 28). It has a



smooth, concave proximal end forming the chief support of the ulna. The anterior surface is convex transversely, while the posterior is concave. It articulates with the intermedium by two facets on either extremity of the internal border. The intervening border being concave is not in contact with that of the intermedium.

There are five small elements in the distal row of the carpus. Carpale one is a small ossicle-like bone wedged in between the ends of Metacarpal I and the radiale on the posterior side. It is not visible from the front aspect. In the forefoot of specimen No. 5473, this element was in position but remained as a distinct bone. In No. 4277, however, it is fused with both the radiale and Metacarpal I and is hardly recognizable.

The second carpale in No. 4277 is a small, flattened, rectangular element which was retained in position on the proximal end of Metacarpal II. Its thin, anterior border is visible in fig. 29 between the radiale and Metacarpale II.

The third carpale is a wedge-shaped element coossified about equally with the posterior part of the surfaces of the radiale and intermedium. It articulates slightly with Metacarpal III, and although in other specimens it is visible from a front view of the foot, in this one it is not.

Carpale five, seen from the front, is a lozenge-shaped element interposed between the outer distal surface of the ulnare and the proximal end of Metacarpal V. Marsh has represented this element in the foot of *C. dispar* as contributing to the ulnar surface, but in the specimen here described, an outer extension excludes it from the ulnar surface.

*The metacarpus.*—Metacarpal I is much the shortest element of the series and in adult individuals is always fused with the radiale. The inner border of the proximal end rises to the level of the dorsal surface of the radiale and contributes slightly to the articulating surface for the radius. The distal end is convex dorso-ventrally with a pronounced median depression or groove. The short shaft is angular in cross section, being wider than deep. Fore and aft on the external lateral margin of the proximal end are two antero-posteriorly elongated facets which articulate with corresponding facets on the internal margin of Metacarpal II.

Metacarpal II is more than twice the length of the preceding and more slender. The proximal end is subtriangular in outline, its antero-posterior diameter being the greater. The articular surface of this end is comparatively smooth and gently convex antero-posteriorly. The shaft is somewhat constricted but expands again at the distal end, more especially in its transverse diameter. The external border of the distal end is produced distally below the internal, which deflects the phalanges of this digit mesially. The



posterior border is deeply concave transversely, being a continuation posteriorly of the median depression of this end. The proximal half of the external lateral surface is concave antero-posteriorly, forming a depression which receives a rugose convex surface on the internal lateral surface of Metacarpal III. The distal lateral surfaces are quite smooth.

Metacarpal III is the longest and most robust element of the five. Its proximal end is subtriangular in outline, being longer than wide. The shaft is constricted and at its smallest part would be subcircular in cross section. The distal end is expanded both antero-posteriorly and transversely. Like Metacarpal II this end is convex antero-posteriorly and concave transversely, although the median depression is not so pronounced as in Metacarpals I and II. The external lateral surface of the proximal end is roughened and during the life of the animal it probably had direct cartilaginous articulation with Metacarpal IV. As mentioned above, the proximal end articulates principally with the intermedium and slightly with carpale three.

Metacarpal IV is shorter and more slender than Metacarpal II, the shaft being more rounded. Viewed from above, the proximal end is subtriangular and has a smooth concave end which articulates closely with the distal end of carpale four. The distal end is proportionately less expanded than the preceding metacarpals, and unlike them shows no pronounced median depression except on the anterior border.

Metacarpal V is the most slender of the series, although longer than Metacarpal I. Seen from above the proximal end is triangular and like Metacarpal IV has a smooth, transversely concave articular surface for union with carpale five. On the internal lateral surface near the proximal end is a shallow concave depression which articulates with an outward projection on the postero-external angle of the proximal end of Metacarpal IV, forming rather a weak union with that digit. The shaft is constricted, especially antero-posteriorly, which gives it a flattened aspect. The distal end is but little expanded, being convex antero-posteriorly, without median depression.

*Measurements of metacarpals of Specimen, Cat. No. 4277, U.S.N.M.*

Metacarpals.	I.	II.	III.	IV.	V.
	mm.	mm.	mm.	mm.	mm.
Length .....	26	61	76	60	40
Breadth of proximal end .....	33	31	35	40	38
Breadth of distal end .....	30	35	37	32	25

*Phalanges*.—The phalangeal formula beginning with the first digit is 2, 3, 3, 3, 2.

The proximal phalanx of the first digit is short, with lateral and dorsal surfaces quite evenly rounded and palmar surface flattened.

The internal side is longer than the external. The proximal articular end is concave supero-inferiorly, with a blunt median keel for articulation with the groove on the distal articular surface of Metacarpal I. The distal end is regularly convex supero-inferiorly and concave transversely. This description is based on the phalanx of the left forefoot of *C. browni*. The ungual of Digit I is missing on all of the feet studied, but in the specimen shown in fig. 29 this element has been provisionally restored.

The proximal phalanges of Digits II and III are short, stout, block-like bones. The proximal articular ends are concave supero-inferiorly, with a median concave depression. The second phalanges of the above digits are much shortened, with concave proximal and convex distal ends. The palmar surfaces are flattened and produced posteriorly into thin sheets which lie under the distal ends of the proximal phalanges of their respective digits. This posterior extension is especially pronounced in the second phalanx of Digit IV.

Digits II and III are terminated by relatively large, pointed unguals, which were undoubtedly sheathed in horny claws, as indicated by a pair of lateral grooves on each ungual. The ungual of Digit II is considerably depressed; the proximal end is subtriangular in outline with concave supero-inferior surface. The median dorsal surface is produced posteriorly and overhangs somewhat this articular end. The proximal end of this ungual of Digit III is higher than wide and in outline is irregularly rounded. The articular end is more deeply concave than ungual two. The anterior end is deflected toward the foot of the opposite side and is sharply pointed. The proximal phalanx of the fourth digit is much depressed, especially at the distal end, and expanded transversely at the proximal end. The articular surface of this end is concave supero-inferiorly with only a faint indication of a keel on the superior part of the median surface. The palmar surface is flattened. The transverse extent of the distal end is much less than the proximal. It is convex supero-inferiorly with a suggestion of a concave median groove. The second phalanx of this digit is very short and supports a small, rounded, hemispherical, terminal phalanx which in life was probably embedded within the integument of the foot. The proximal end of the latter is indicated by a concave surface.

The proximal phalanx of Digit V is the most slender of the series. The upper articular end is about evenly concave in both transverse and vertical directions and tapers without noticeable constriction to the distal end, which is convex supero-inferiorly. The terminal phalanx of this digit is an irregular button-like ossicle.

From the above description and figures of the manus of *Camptosaurus* it will be seen that the weight of the body was borne principally on the three median digits, and that through disuse the fifth

was becoming atrophied. While this has not yet resulted in the elimination of any of the digits, yet the fifth is fast approaching a functionless condition.

*Measurements of phalanges of Specimen, Cat. No. 4277, U.S.N.M.*

Digits.	I.	II.	III.	IV.	V.
	mm.	mm.	mm.	mm.	mm.
Greatest length first row of phalanges.....	a 21	26	31	26	23
Greatest length second row of phalanges.....		24	26	a 16	6
Greatest length third row of phalanges.....		b 48	b 50	a 10	-----

<sup>a</sup> Measurements of elements of left forefoot of No. 4282, is a slightly smaller individual.

<sup>b</sup> Estimated, elements incomplete.

THE PELVIS.

The pelvis of *Camptosaurus*, as shown in Plates 15 and 16, is quite characteristic of the genus. It is composed of the three elements, the ilium, ischium, and pubis, usually found in the pelvis of the

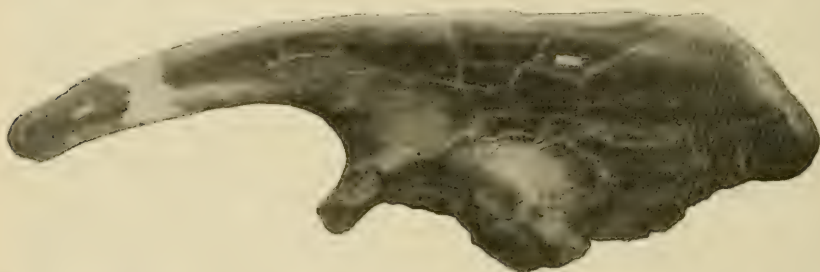


FIG. 29.—LEFT ILIUM OF CAMPTOSAURUS DISPAR MARSH. CAT. No. 5473, U.S.N.M.;  $\frac{1}{3}$  NAT. SIZE. EXTERNAL VIEW. END OF PUBIC PEDUNCLE MISSING. FROM A PHOTOGRAPH.

Dinosauria. The long, slender post-pubis, reaching to the end of the equally long shaft of the ischium, is distinctive of this group. With the exception of the pubis, the parts described below are of specimen Cat. No. 4282, U.S.N.M.

*The ilium.*—The ilium is an elongated plate-like bone, resembling in most of its characteristics the corresponding element of *Iguanodon*. The preacetabular process is long, narrow, and compressed laterally. The ilia of this specimen lack the anterior termination, but in *C. dispar*, as shown by the ilium of Cat. No. 5473, U.S.N.M., the end is somewhat spatulate (see fig. 29). This long, slender process extends forward and outward, overhanging the posterior ribs. The superior border of the ilium is thickened and rounded transversely, and at the posterior end descends for a distance of 90 mm., at an oblique angle, gradually thickening to the point where it reaches the infero-internal plate. Viewed laterally the ilium has a width of 87 mm. from where the superior border begins to descend to the border where the inner



shelf is given off. The acetabular arch is bounded anteriorly by a rather wide but slender pubic peduncle directed downward and forward. The posterior peduncle for the ischium is heavy, broadly swelled, with two roughened surfaces, more especially the posterior, which meet at an obtuse angle. The posterior and more inferior one, which is somewhat cupped, is for the articulation of the ischium. The roughened anterior surface appears to be for the attachment of the heavy pads of cartilage and ligaments which bound the pelvic bones together. Posterior to this process the inferior border is a sharp edge, which, as it extends backward gradually turns from a vertical to a nearly horizontal position, with a rounded, thickened, posterior termination. The upper half of the internal surface is smooth and gently concave from end to end. On the lower median internal surface are roughened cupped depressions, their greatest extent being vertical, for the articulation of the sacral ribs (see *x*, Plate 15). These surfaces are separated by narrow, smooth, concave, nonarticular tracts. A shallow, roughened longitudinal groove

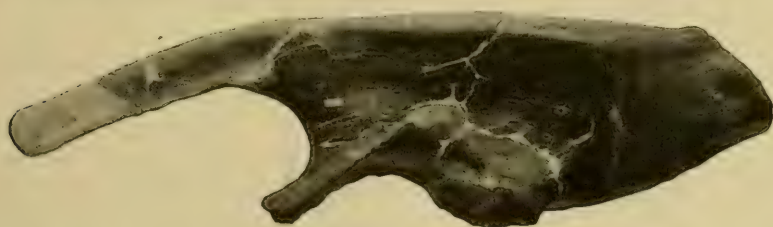


FIG. 30.—LEFT ILIUM OF CAMPTOSAURUS BROWNI. HOLOTYPE. CAT. No. 4282, U.S.N.M.;  $\frac{3}{4}$  NAT. SIZE. EXTERNAL VIEW. ANTERIOR END OF PREACETABULAR PROCESS RESTORED AFTER THAT OF THE LEFT ILIUM OF No. 5473 (SEE FIG. 29). FROM A PHOTOGRAPH.

on the thickened internal edge of the shelf-like projection mentioned above, may be for the reception of the transverse process of the fifth sacral. The greatest vertical width of the ilium is over the ischial peduncle.

The ilium is one of the most characteristic bones of the skeleton, and while the description given above shows all of the essential characters of the *Camptosaurus* ilium, it is found that in other species there are great differences of contour and proportion.

*Measurements of Specimen, Cat. No. 4282, U.S.N.M.*

	mm.
Greatest length of left ilium from posterior end to center of preacetabular notch .....	392
Greatest width over ischial process .....	75
Greatest width from middle of acetabulum .....	115
Greatest expanse of acetabulum .....	161

*The ischium.*—The ischium is larger than the pubis and distally consists of a slender rod-like shaft which curves downward with an



expanded hammer-like end (see 1a, fig. 31). The distal ends appear to have been in contact as well as the borders of the lower half of their shafts. In *C. browni* this bone is lightly constructed, in this respect approaching the ischia of *C. medius*. The proximal end has a widely expanded Y-shaped extremity with two distinct articular faces (see 18, Plate 16), the one for the posterior peduncle of the ilium being the heavier. Its articular surface is rugose and deeply cupped. The articular surface for contact with the pubis is borne on a thin, quad-

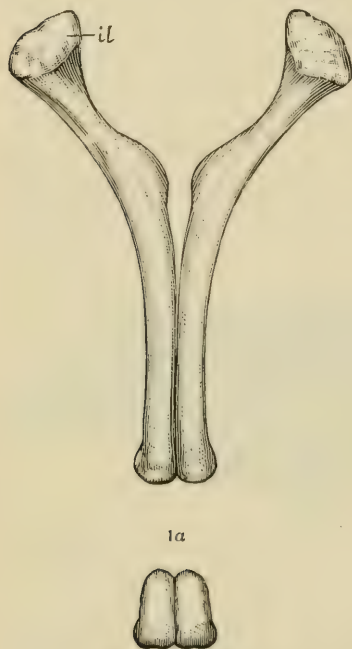


FIG. 31.—ISCHIA OF CAMPTOSAURUS MEDIUS MARSH. SUPERIOR VIEW. YALE MUSEUM;  $\frac{1}{2}$  NAT. SIZE. *il*, ILIAC SURFACE; *1a*, DISTAL ENDS OF SAME. AFTER MARSH.

rilateral plate which extends downward and forward from the main shaft of the bone, and its upper antero-posterior concave border completes the acetabular boundary. The straight, truncated end of this plate is flat and thickened transversely, and when in position abuts against an opposing articular face on the posterior end of the pubis at about the middle line of the acetabulum. The lower anterior border is also thickened and is in contact with a depressed articular surface on top of the postpubis, just posterior to the pubic foramen. Behind, the expanded head contracts rapidly, but again widens on the inferior border into a thin, lip-like, downturned, obturator process, against which the rod-like shaft of the postpubis rests (see Plate 16). Below this process the shaft contracts and continues as a curved, rod-like shaft to the distal extremity. The position of the obturator process, well up toward the articu-

lar end, at once distinguishes the ischium of *Camptosaurus* from *Hyosilophodon foerli*, which has this process about midway between the two ends.

*Measurements of Specimen, Cat. No. 4282, U.S.N.M.*

	mm.
Greatest length of left ischium.....	545
Greatest width of proximal end.....	194
Greatest width of distal end.....	79

*The pubis.*—The description to follow is based on the pubis of *C. dispar*, No. 1878, Yale Museum, the postpubis from *C. medius*, No. 1880, Yale Museum (see *p'*, Plate 16).

As shown in fig. 32, the pubis in *Camptosaurus* is composed of a flattened prepubic element and an elongated, curved, slender post-

pubis. The anterior portion is a thin, flat, vertical blade of bone, when articulated extends forward, downward, and slightly outward. The superior border is gently concave antero-posteriorly, and near the proximal end expands transversely into a triangular, roughened surface for contact with the pubic peduncle of the ilium. The proximal end is expanded transversely, forming a heavy, concave end which bounds part of the anterior and inferior borders of the acetabulum.

The lower part of the proximal end has a rugose surface for contact with the antero-infero projection of the proximal end of the ischium. On the lower internal border of the proximal end the postpubic bar is developed, which extends backward and downward beneath and parallel with the ischium, reaching to the end of that bone. Between the anterior end of the postpubis and the posterior acetabular surface of the prepubis is a large pubic foramen, which, in some individuals at least, does not appear to have been entirely closed posteriorly. While the notch is closed in three individuals studied, the union of the two surfaces is not to coalescence, the suture in all instances being visible.

Posterior to the upward projection of the superior surface of the postpubis is a shallow, roughened depression which was in contact with the lower anterior prolongation of the

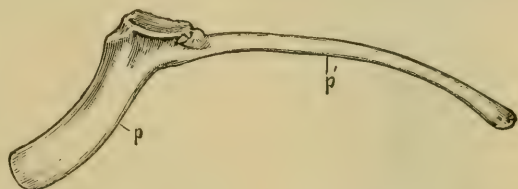


FIG. 32.—LEFT PUBIS OF CAMPTOSAURUS DISPAR MARSH. PARATYPE. NO. 1878, YALE MUSEUM;  $\frac{1}{2}$  NAT. SIZE. EXTERNAL VIEW. *p*, PUBIS; *p'*, POSTPUBIS. AFTER MARSH.

ischium. A cross section at the broken end of the postpubis of Cat. No. 4282, U.S.N.M., shows it to be subcircular in outline. The distal end is slightly expanded, especially in the ventral direction. In No. 1880, Yale Museum, holotype of *C. medius*, in which this element is complete, the postpubis is 480 mm. in length. Its distal end is 23 mm. wide in the vertical direction.

The anterior ends of the pubes do not meet medially.

#### THE HIND LIMB.

The hind limb and foot in *Camptosaurus* is about twice the length of the fore limb and foot and much more robust. The tibia is slightly shorter than the femur. There are four ossified elements in the tarsus, the calcaneum and astragalus being distinct.

*The femur.*—Unfortunately the femora are lacking in Cat. No. 4282, U.S.N.M., but in a second, larger individual both are present, and two more, representing as many individuals, were found in the collection. All are remarkably free from distortion, and in a fine state of preservation. The description to follow is based upon the femora of No. 5818 (see fig. 33).

The femur is the most robust bone of the skeleton. It has a curved shaft, and is compactly and strongly built throughout. The forward arctuation of the shaft distinguishes this bone from all other known American predentate dinosaurs excepting *Laosaurus* and *Dryosaurus*. A compressed inner or fourth trochanter (*b*, fig. 33) of the pendant type is developed on the postero-internal margin of the shaft. Dollo has called attention to this type of trochanter in *Iguanodon*



FIG. 33.—RIGHT FEMUR OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5818, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. INNER VIEW. *a*, LESSER TROCHANTER; *b*, INNER TROCHANTER; *c*, INNER CONDYLE; *h*, HEAD. FROM A PHOTOGRAPH.

as indicating a powerful caudo-femoral musculature, as in some birds. In *Camptosaurus*, however, it appears more prominently developed than is found in any of the European representatives of this group. The fourth trochanter begins to develop somewhat above the middle of the shaft, the apex being directed downward and inward toward the distal end of the bone. Just anterior to the trochanter is a shallow vertical depression with a markedly rugose surface which extends out on the internal surface of the trochanter. The head (*h*, fig. 33) is well developed and subglobular in form, and is attached by a short, thick neck at nearly a right angle to the main axis of the shaft. The articular surface of the head is somewhat rugose, and this rugosity is continued along the superior surface of the greater trochanter to its external border. A prominent lesser trochanter (*a*, fig. 33) rises on the antero-external surface of the upper part of the shaft, nearly to the height of the greater trochanter, as a transversely compressed blade. Posteriorly the lesser trochanter is separated from the shaft by a deep, narrow cleft. Behind the head is a pronounced groove separated from a second concave depression on the posterior median

surface of the shaft by a heavy, rounded, longitudinal swelling. The superior surface of the greater trochanter (2, fig. 42) is wider and more gently rounded antero-posteriorly than the head. The distal end has the usual condyle shape, though the inner condyle (*c*, fig. 33) is much more robust than the outer. The two condyles are separated by a deep, intercondylar groove, wider at the bottom than the top. Both condyles project decidedly backward. The anterior intercondylar groove (2, fig. 42) is wide and of moderate depth, con-



trasting strongly with the deep, narrow, almost "tunnel-shaped," anterior-intercondylar groove in *Trachodon*. The shaft of the femur appears to be somewhat twisted, due to the alteration of the aspect of its surfaces, that which at the proximal end is external becoming at the distal end anterior. There is a small roughened area on the extero-posterior angle of the distal portion of the shaft for the attachment of muscles, and just above the beginning of the intercondylar depression or groove on the anterior surface is a second roughened patch. The outer surface of the outer condyle is decidedly concave, forming a wide, longitudinal depression at the distal end, in which a large tendon must have passed.

*Measurements of Specimen, Cat. No. 5818, U.S.N.M.*

	mm.
Greatest length of right femur.....	592
Greatest diameter of proximal end.....	190
Greatest diameter of distal end.....	178

*The tibia.*—The tibia in *Camptosaurus* is shorter than the femur, in which respect it may be distinguished from *Laosaurus*, *Dryosaurus*, and *Hypsilophodon foxii*. It is constricted medially, but greatly expanded at either extremity, the longer axes of the expanded ends being at nearly right angles to one another. The proximal end of the tibia shows a division of the articular surface into two condyles, which project posteriorly, separated by an intercondylar groove, the internal one (*c*, fig. 34) being the heavier. A large enemial crest (*b*, fig. 34) projects outward from the upper end of the shaft in front of the external condyle.

The distal end is divided into two malleoli, of which the inner is the shorter and heavier, its articular surface looking downward and forward, while the external is longer and thinner and looks directly downward. These are separated on the front surface of the bone by a shallow groove. As in *Triceratops*, the outer malleolus falls below the superior border of the astragalus. Its flattened anterior surface was in contact with the distal extremity of the fibula. The posterior surface of the distal end of the tibia is angularly convex transversely.



FIG. 34.—RIGHT TIBIA AND ASTRAGULUS OF CAMPTOSAURUS DISPAR MARSH. CAT. NO. 5818. U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. INNER VIEW. *a*, ASTRAGULUS; *b*, ENEMIAL CREST; *c*, INNER CONDYLE. FROM A PHOTOGRAPH.



*Measurements of Specimen, Cat. No. 5818, U.S.N.M.*

Greatest length of right tibia.....	531
Greatest diameter of proximal end.....	222
Greatest diameter of distal end.....	90

*The fibula.*—The fibula of No. 1877, Yale Museum, is a slender bone, being somewhat shorter than the tibia. It has a flattened shaft above, which is subcylindrical below, with flattened expanded extremities. The face of the proximal end which was applied to the tibia is concave antero-posteriorly, while the outer surface is convex. The articular surface of this end is nearly straight antero-posteriorly, but roughened and gently rounded transversely. The expansion of the upper end takes place more especially toward the anterior border which overhangs considerably the constricted shaft. As with the tibia, planes passed through the longer axes of the expanded articular ends would cut one another at nearly right angles. Internally the distal extremity is plain and was closely applied to the opposing flattened surface of the outer anterior face of the tibia. The articular end is roughened and concave and viewed from below is semicircular in outline. The shaft has a small medullary cavity. The distal end articulates closely with the upper surface of the calcaneum.

## THE HIND FOOT.

*The astragalus.*—The astragalus, although closely applied, was not ankylosed to the tibia, even in adult individuals. Its upper surface is the counterpart of the inner articular surface of the tibia.

The upper surface (see *a*, fig. 34) is deeply concave from front to back and divided by a ridge, which marks out two portions corresponding to the inner and part of the outer tibial malleolus. These two surfaces meet one another at an obtuse angle. The distal surface is convex antero-posteriorly, with a broad, shallow depression medially, making this surface slightly concave transversely. The anterior margin is a thickened lip. The posterior margin is stout, and viewed from above, terminates in a heavy, angular, posterior point. The inner end is comparatively thin and probably non-articular, although a prominently developed projecting knob on the antero-internal angle appears to have been closely apposed to the distal inner surface of the fibula. The anterior half of the external depression of the dorsal surface is nonarticular and did not come in contact with the tibia, but formed the walls of an opening leading down between this bone and the *os calcis*. The outward knob-like projection overlaps the outer surface on the distal part of the tibia. On the anterior internal surface, just below the superior border, is an elongated pit.

There is no ascending process on the astragalus of *Camptosaurus*.

*Measurements of Specimen, Cat. No. 5818, U.S.N.M.*

	mm.
Greatest transverse diameter .....	139
Greatest antero-posterior diameter .....	95

*The calcaneum.*—Seen from the outside, the calcaneum is subcrescentic in outline. The upper surface is divided by a diagonal ridge into two articular faces. The anterior one, which is above the heavier end of the bone, receives the distal end of the fibula. The posterior articular portion has its surface below the level of the fibular surface and is deeply concave antero-posteriorly, and receives the outer part of the tibial malleolus. This portion has the greatest transverse diameter. The posterior margin is rounded transversely and turns up as a thickened rounded lip. The ventral surface is convex from front to back, the inner border being in contact with the outer edge of the astragulus. The outer surface vertically is gently concave. The calcaneum is represented in two individuals in the National Museum, Cat. Nos. 5473 and 5961, also in the holotype of *C. dispar*, No. 1877, Yale Museum, which, being the most complete element, furnished the following measurements:

*Measurements of Specimen, No. 1877, Yale Museum.*

	mm.
Greatest extent antero-posteriorly of calcaneum.....	87
Greatest extent transversely of calcaneum.....	55

*Distal tarsals.*—The distal row of tarsals (see *t*, fig. 35) in *Camptosaurus* consists of two flattened, cushion-like bones, which remain distinct, never fused with the metatarsals, as Hulke has suggested in *Iguanodon*, and whose separateness would be restricted to the embryo. The external one, viewed from above, is subtriangular in outline. Its proximal surface is shallowly cupped, the narrowed portion being directed backward. The distal articulating surface is concave antero-posteriorly and fits closely to the proximal end of Metatarsal IV, as shown in fig. 35. There are deep longitudinal pit-like depressions on the anterior and internal surfaces. Both proximal and distal articulating surfaces are smooth. The tarsal borne by Metatarsal III is an irregular elliptical shaped bone, somewhat thinner than the outer. Its distal articulating surface and all of the surrounding edges are roughened and pitted. This surface is slightly convex, while the proximal surface is gently concave and quite smooth except near the edges. In specimen, Cat. No. 4277, U.S.N.M., these elements have been retained by the matrix in their mutual relationship with the metatarsals, so there can be no question concerning their exact position. Even without this positive evidence, the conformation of their surfaces with the proximal ends of the metatarsals would have enabled one to place them accurately.

## Measurements of Specimen, Cat. No. 4277, U.S.N.M.

Greatest transverse diameter of outer tarsal.....	52
Greatest antero-posterior diameter of outer tarsal.....	72
Greatest transverse diameter of inner tarsal.....	64
Greatest antero-posterior diameter of inner tarsal.....	92

*The metatarsals.*—There were three functional digits in the hind foot, the first being rudimentary and the fifth wanting. The metatarsals are much longer and heavier than the metacarpals, the third

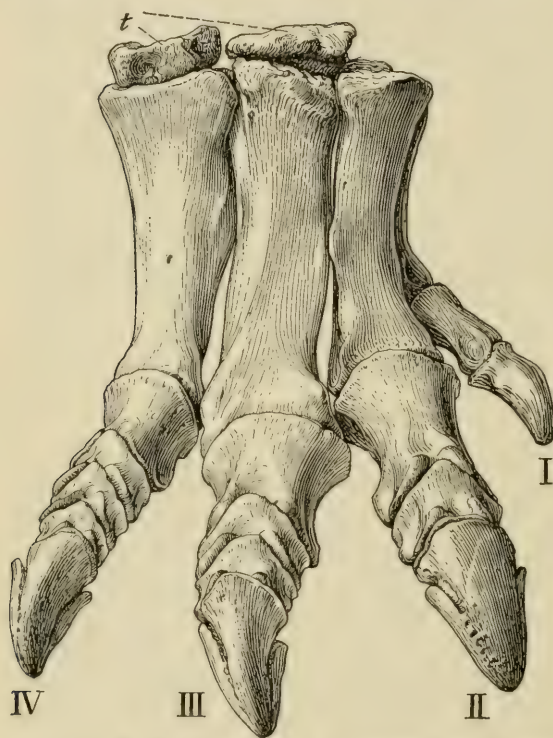


FIG. 35.—RIGHT HIND FOOT, CAMPTOSAURUS DISPAR MARSH. CAT. NO. 4277, U.S.N.M.;  $\frac{1}{2}$  NAT. SIZE. SEEN FROM THE FRONT: *t*, TWO TARSAI BONES OF THE DISTAL ROW; *I*, *II*, *III*, *IV*, FIRST TO FOURTH DIGITS. UNGUALS OF DIGITS *I*, *III*, AND *IV* DRAWN FROM THE FEET OF OTHER INDIVIDUALS.

being the longest. The proximal ends of the second, third, and fourth metatarsals are in the closest mutual apposition, their shafts being closely applied for about one-half of their length. The third and fourth support the two cushion-like tarsalia.

The metatarsal of the first digit is a short, splint-like, irregularly curved bone, with a smooth, rounded proximal end compressed laterally. The thickened rugose distal articular end looks out obliquely from the main axis of the shaft, and supports two phalanges. It appears quite as Marsh has described it as being rudi-

mentary and probably did not reach the ground. It articulates loosely with Metatarsal II, lying in a broad, shallow, longitudinal depression on the inner proximal half of this metatarsal.

The second metatarsal is slightly longer than the fourth, the third being longest. The proximal end is compressed transversely, but is much lengthened antero-posteriorly. The face which is applied to the third is plane, while the outer surface is irregularly concave. The articular end is gently convex antero-posteriorly, and has a roughly pitted surface. Just below the middle of the shaft on the antero-



external border a thin lip-like process is developed which laps over and is closely applied to a roughened surface on the antero-internal border of the shaft of Metatarsal III. At this point the shaft is bent outward, which throws the distal part away from the median bone. The distal end is stout, and subquadrilateral in outline, except that it is bisected by a deep, rounded notch on the posterior border. This end is rounded antero-posteriorly. The pits for the attachment of lateral ligaments are large and fairly deep. The proximal end of the third metatarsal is roughly triangular in outline, the thickened portion being in front. The articular surface is roughened and slightly concave for the reception of the flattened tarsale of the distal row. The inner surface of the proximal half is plane, but below, this border of the shaft is rounded. Viewed anteriorly the bone remains about the same width, being slightly expanded at the distal end. Viewed laterally, however, the shaft contracts rapidly from the proximal toward the distal pulley-like articular end. The external surface of the proximal end has two oblique faces, which are opposed by the excavated internal surface of the fourth metatarsal. The pits for the attachment of lateral ligaments are large but shallow.

Seen from the proximal end the fourth metatarsal is subtriangular, the apex being directed outward. The slightly roughened articular surface in front is concave and receives the distal tarsale closely. The internal surface of the upper half is roughened and fits closely to the upper surface of the third metatarsal. The shaft is compressed antero-posteriorly and is wider than thick. As in the second metatarsal the lower half diverges outwardly and is free from the median or third metatarsal. The distal end is expanded, more especially antero-posteriorly than laterally. The distal articular end is rounded and roughened on the posterior but smooth on the anterior half. The pits for the lateral ligaments are large, the internal being shallow, the external very deep. The numbers of the phalanges, beginning with the first, are 2, 3, 4, 5, and correspond, as Hulke <sup>a</sup> has pointed out, to the first, second, third, and fourth toes in the foot of existing lizards and birds. *Hypsilophodon foxii* has the same formula. The proximal phalanges are rather long, with pulley-shaped distal and concave proximal ends. The phalanges have their articulating ends closely applied to one another. A median rounded vertical ridge on the proximal end fits into a corresponding depression on the proximal end of another, thus forming a strong union which would allow but little lateral motion. There are deep, well-defined lateral pits for the attachment of ligaments on most of the phalanges. The second, third, and fourth phalanges of Digit IV are considerably more shortened than the other phalanges. The ungual phalanges

<sup>a</sup> Phil. Trans. Roy. Soc. London, CLXXIII, 1882, p. 1053.



are long, pointed, and slightly curved longitudinally and laterally, being deflected inward. They are somewhat depressed, except the ungual of Digit I, which is higher than wide, and more sharply pointed. They were undoubtedly incased in compressed pointed claws, as indicated by a pair of lateral grooves on each ungual (see fig. 35). The ungual of the second digit is the more robust of the series.

*Measurements of the right hind foot of Specimen, Cat. No. 4277, U.S.N.M.*

Digits.	I.	II.	III.	IV.
	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
Greatest length of metatarsals.....	133	212	234	202
Greatest antero-posterior diameter proximal end of metatarsals.....	15	118	106	77
Greatest transverse diameter of proximal end of metatarsals.....	6	55	66	81
Greatest transverse diameter of distal end of metatarsals.....	26	64	76	45
Greatest length 1st row phalanges.....	58	95	85	63
Greatest length 2d row phalanges.....	<sup>a</sup> 59	69	53	39
Greatest length 3d row phalanges.....		94	43	30
Greatest length 4th row phalanges.....			<sup>a</sup> 90	29
Greatest length 5th row phalanges.....				<sup>a</sup> 81

<sup>a</sup> Measurements from other individuals of about same proportions as No. 4277.

#### THE GENUS CAMPTOSAURUS.

In a paper published in December, 1879,<sup>a</sup> Prof. O. C. Marsh proposed the genus *Camptonotus*, and at the same time described two species, *C. dispar* and *C. amplus*, both from the Morrison beds (Atlantosaurus beds of Marsh) of the Upper Jurassic. In the same article he proposed the family Laosauridae to include the two genera *Laosaurus* and *Camptonotus*.

In 1881,<sup>b</sup> without comment, he proposed the family Camptonotidae, under which the following genera were included: *Camptonotus*, *Laosaurus*, *Nanosaurus*, and *Diracodon*. In 1882<sup>c</sup> he briefly defined the family, including in it the European genus *Hypsilophodon*, *Diracodon* being removed to the Stegosauridae.

The name *Camptosaurus* was proposed by Marsh in 1885<sup>d</sup> to replace *Camptonotus*, preoccupied.

Dollo,<sup>e</sup> in 1888, gave an emended definition of the family, using the older term Camptonotidae, under which he placed the two genera *Camptonotus* and *Hypsilophodon*. To distinguish the former from the latter, "*Camptonotus*" is defined as follows: "Two phalanges in manus-digit-V. Preacetabular process of the ilium slight. No rudiment of pes-digit-V."

In 1889, Lydekker<sup>f</sup> referred three species to the genus *Camptosaurus*, *C. leedsi*, *C. caldensis*, and *C. prestwichii*. Seely's genus

<sup>a</sup> Amer. Journ. Sci., XVIII, 1879, pp. 501-503.

<sup>b</sup> Idem, XXI, 1881, p. 423.

<sup>c</sup> Idem, XXIII, 1882, p. 84.

<sup>d</sup> Idem, XXIX, 1885, p. 169.

<sup>e</sup> Compt. rend. Acad. Paris, CVI, 1888, pp. 775-777.

<sup>f</sup> Quart. Journ. Geol. Soc. London, XLV, 1889, pp. 47, 48.

*Cumnorina* being considered a synonym. In 1890<sup>a</sup> he characterized the genus as follows:

Teeth simpler than in the typical group of *Iguanodon*. Cervical vertebrae opisthocoelous; sacral flattened inferiorly and not ankylosed; manus with five normal digits. Ilium typically deep with short and pointed pre- and postacetabular processes, the latter having a distinct ventral plate; pubis relatively stout and long as ischium. Femur slightly longer than tibia, with curved shaft and pendant inner trochanter; typically four functional digits in pes.

In 1894,<sup>b</sup> Marsh published a restoration of the skeleton of *Camptosaurus dispar*, and additional characters relating to the osteological structure were noted. Four months later,<sup>c</sup> he briefly described the two species, *C. medius* and *C. nanus*, and at the same time characterized the genus as follows:

Premaxillaries edentulous with horny beak. Teeth large, irregular, and few in number. A supra-orbital fossa. Cervical vertebrae long and opisthocoelous. Lumbar present. Five free vertebrae in sacrum, with peg-and-notch articulation. Limb bones hollow. Fore limbs small. Sternum unossified. Five functional digits in manus. Prepubis long and broad, postpubis elongated. Femur longer than tibia. Metatarsals short. Three functional digits in pes: the first rudimentary and the fifth wanting.

In 1895<sup>d</sup> Marsh redefined the family Camptosauridae, retaining in it only the genus *Camptosaurus*, the other genera being removed to separate families proposed for them. This definition was repeated, with a few additions, in 1896, in his "Dinosaurs of North America."<sup>e</sup>

In 1899, Nopcsa<sup>f</sup> gives a brief preliminary description of a new species, *C. inkeyi*, from the Cretaceous of Hungary, and in 1901<sup>g</sup> placed the genus under the subfamily Camptosauridae.

In 1902, Hay<sup>h</sup> included under the family Camptosauridae<sup>i</sup> the

<sup>a</sup> Cat. Fossil Reptilia and Amphibia in Brit. Mus., Suppl. to Pt. 4, 1890, p. 259.

<sup>b</sup> Amer. Journ. Sci., XLVII, 1894, pp. 245, 246, pl. vi.

<sup>c</sup> Idem, XLVIII, 1894, pp. 85, 88.

<sup>d</sup> Idem, L, 1895, p. 497.

<sup>e</sup> 16th Ann. Rept. U. S. Geol. Surv., Pt. 1, 1896, p. 243.

<sup>f</sup> Denk. k. Akad. Wien, LXVIII, 1899 (1900), p. 579.

<sup>g</sup> Földtani Közlemény, Budapest, XXXI, 1901, p. 210.

<sup>h</sup> Bull. No. 179, U. S. Geol. Surv., 1902, p. 501.

<sup>i</sup> Laosauridae Marsh has priority over Camptosauridae Marsh, and if *Laosaurus* is to be included in the same family with *Camptosaurus*, the former name should be retained. On the other hand, if the two forms represent distinct families, as originally proposed by Marsh, Camptosauridae is represented by the genus *Camptosaurus*, and Laosauridae by the genera *Laosaurus* and *Dryosaurus*. The superfamily Iguanodontidea proposed by Hay in his Bibliography and Catalogue of the Fossil Vertebrata of North America (p. 500), should then include the families Camptosauridae, Laosauridae, Nanosauridae, Trachodontidae, and the European Iguanodontidae and Hypsilophodontidae. For obvious reasons, *Thespesius* Leidy should be removed from the Iguanodontidae to the Trachodontidae.

genera *Camptosaurus*, *Laosaurus*, and *Dryosaurus*, *Nanosaurus* being retained under the family Nanosauridæ as originally proposed by Marsh.

In the same year, Zittel<sup>a</sup> defines the genus *Camptosaurus* thus:

Attaining a total length of about 10 m. Cervical ribs short; dorsal vertebrae amphiplatan; sacrals not ankylosed. Pubis robust, postpubis of equal length with the long and slender ischium. Pendant inner fourth trochanter of femur marked. Proximal tarsals separated.

As shown by a recent study of the typical specimens in conjunction with all other available material, it is found that the earlier definitions of the genus, as briefly reviewed above, are in some respects in error. Such inaccuracies as have been detected can, in most instances, be attributed to the incompleteness of the material at the command of the earlier authors.

The characters displayed by the discovery of new material, combined with a restudy of the typical specimens, show that the genus *Camptosaurus* may now be characterized as follows:

*Generic characters.*—*Premaxillaries edentulous, with horny beak. Teeth large, irregular and comparatively few in number. A supra-orbital fossa. Cervical vertebra posterior to the third opisthocœlous manus with five digits, metacarpal of first digit ankylosed with radiale. Ilium with long preacetabular process. Pubis well developed, with broad anterior blade, postpubis elongated reaching end of ischium. Ischium with long shaft terminated by an expanded hammer-like end. Femur curved, longer than tibia, with pendant inner trochanter extending on to the distal half of the shaft. Astragulus and calcaneum free, former without ascending process. Pes robust with four digits, first being rudimentary.*

*Camptosaurus dispar* is the type-species of the genus, and, as will be discussed later, was founded on the remains of at least two and maybe three individuals, all from the Jurassic, Quarry No. 13, near Como, Albany County, Wyoming. Eight species have been described as pertaining to this genus, of which four are American and four European. An alphabetical list of the species assigned to the genus is given below.

#### ALPHABETICAL LIST OF SPECIES.<sup>b</sup>

*Camptosaurus amplus* Marsh. (No. 1879, Yale University Museum.)

*Camptosaurus browni*, new species. (Cat. No. 4282, U.S.N.M.)

<sup>a</sup> Text-book of Paleontology, English Translation, II, 1902, p. 238.

<sup>b</sup> In Földtani Közlöny, Budapest, XXXI, 1901, p. 210, Nopcsa inadvertently includes *Dryosaurus altus* (Marsh) in a list of the described species of *Camptosaurus*. Marsh first described this form as *Laosaurus altus* and later referred it to *Dryosaurus*. While it represents a closely related genus, it is quite distinct from *Camptosaurus*.



- Camptosaurus depressus*, new species. (Cat. No. 4753, U.S.N.M.)  
*Camptosaurus dispar* Marsh. (No. 1877, Yale University Museum.)  
*Camptosaurus inkeyi* Nopesa. (Location of type unknown.)  
*Camptosaurus leedsi* Lydekker. (Coll. of A. N. Leeds, Eyebury, England.)  
*Camptosaurus medius* Marsh. (No. 1880, Yale University Museum.)  
*Camptosaurus nanus* Marsh. (Cat. No. 2210, U.S.N.M.)  
*Camptosaurus prestwichii* Lydekker. (Museum in Oxford, England.)  
*Camptosaurus valdensis* Lydekker. (No. R167, British Museum.)

#### SYSTEMATIC DESCRIPTION AND REVISION OF SPECIES.

In the description and revision of the various species to follow, Hatcher's method of treatment in his monograph on the Ceratopsia is adopted, with modifications. A reference to the original description of each will first be given, followed by references to the more important literature which further elucidates the species under consideration. These references will be arranged in chronological order.

When possible, the parts constituting the type will be listed and definitely located, also the name of the museum to which each belongs, as well as the distinctive catalogue numbers which have been assigned to them. The locality and geological horizon from which the specimen came, and the name of the collector, when known, will be given, so that in each instance a permanent record of the character and location of the type material will hereafter be available.

In the discussion of the species, the original description of each will first be quoted, followed by a further description of such parts of the skeleton as considered not sufficiently elucidated in the original text, and a presentation of my own views. In conclusion an attempt will be made to give a brief characterization of each valid species.

#### CAMPTOSAURUS DISPAR Marsh.

- Camptonotus dispar* MARSH, Amer. Journ. Sci. (3), XVIII, 1879, pp. 501-503, pl. III.  
*Camptosaurus dispar* MARSH, Amer. Journ. Sci. (3), XXIX, 1885, p. 169.  
*Camptosaurus dispar* LYDEKKER, R. Cat. foss. Reptilia and Amphibia Brit. Mus., Pt. 1, 1888, p. 192, fig. 36.  
*Camptosaurus dispar* MARSH, Amer. Journ. Sci. (3), XLIV, 1892, p. 176, pl. v; XLVII, 1894, pp. 245-246, pl. vi; XLVIII, 1894, p. 85, pl. v, fig. 1; Geol. Mag., Dec. 3, I, 1894, pp. 193-195, pl. vi; 16th Ann. Rept. U. S. Geol. Surv. 1894-95, Pt. 1, 1896, p. 196, pls. LIV, LVI; Compt. rend., 3 me Congrès International de Zoologie, Leyden, 1896, pp. 196-211, fig. 7; Mon. U. S. Geol. Surv., XXVII, 1897, p. 502, pl. xxiii; Amer. Journ. Sci. (4), VII, 1899, p. 232, fig. 2.



*Cumnora* (*Camptosaurus*) *dispar* WILLISTON, Amer. Nat., XXIV, 1890, p. 472.

*Camptosaurus dispar* ZITTEL, Handbuch der Paleontologie, I, 1890, p. 756, fig. 666.

*Camptosaurus dispar* FÜRBRINGER, Jenaische Zeitschr. f. Naturwiss., Jena, XXXIV, 1900, p. 350.

*Camptosaurus dispar* NOPCSA, Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Camptosaurus dispar* HAY, Bull. No. 179, U. S. Geol. Surv., 1902, p. 501.

*Holotype*.—No. 1877 consists of the atlas, axis, seven cervicals, first dorsal, left scapula (lacking upper half of the blade), left coracoid (also incomplete), two femora, tibia, fibula, astragalus, calcaneum, nearly complete pes, and two manus.

*Paratype*.—No. 1877a, so far as I am able to determine, consists of a sacro-dorsal and four sacral vertebræ, all united by suture.

*Paratype*.—No. 1878 consists of the left ilium, pubis, and ischium, figured in the original description, together with a humerus, radius, and ulna.

The description calls for teeth and part at least of the lower jaws. It may be Marsh refers here to a pair of incomplete jaws, No. 1888, in the same collection, but this can not now be absolutely determined.

The above specimens were all collected by Mr. W. H. Reed from Quarry No. 13, Jurassic (Morrison beds), 8 miles east of Como, Wyoming, and are now preserved in the collection of the Yale University Museum.

The original description is as follows:

The present genus is most nearly allied to *Laosaurus*, but differs in several points. The cervical vertebræ are all opisthocoelous, while those known in *Laosaurus* are nearly plane. The pubis, moreover, is broad and thin in front of the acetabulum, and directed well forward. It has a deep, well-marked articular face for the support of the femur. The ischium is expanded at its distal end, and has an extensive surface for union with its fellow. The femur is longer than the tibia.

This genus agrees with *Laosaurus* in one important character, namely, the sacral vertebræ are not coossified. That this is not merely a character of immaturity is shown by some of the other vertebræ in the type specimen, which have their neural arches so completely united to the centra that the suture is nearly or quite obliterated. To this character of the sacral vertebræ the name of the present genus refers. With *Laosaurus* this genus forms a distinct family, which may be called *Laosauridæ*.

The teeth in *Camptonotus* resemble those of *Laosaurus*, and are in a single row in close-set sockets. The rami of the lower jaws were united in front only by cartilage. There are nine cervical vertebræ, all of which bear short ribs, as in the Crocodiles. The dorsal vertebræ have their articular faces nearly plane. The sacral vertebræ in all the known specimens are separate, and their transverse processes are each supported by two centra. The chevrons have their articular faces joined together.

The fore limb is much reduced in size. There are five digits in the manus, supported by nine carpal bones, three of which are united in one on the radial side. The number of phalanges, beginning with the first digit, was 2, 3, 3, 3, 2.

The form and proportion of the various elements of the fore limb are shown in Plate III, fig. 1.

The pelvic arch is quite unlike any hitherto described. In its general form the ilium resembles that of *Morosaurus*, but the proportions are reversed. The massive portion in the present genus is not in front, but behind, as the ischium is larger than the pubis. The relative position and form of the elements of

the pelvic arch are shown in the figure below.

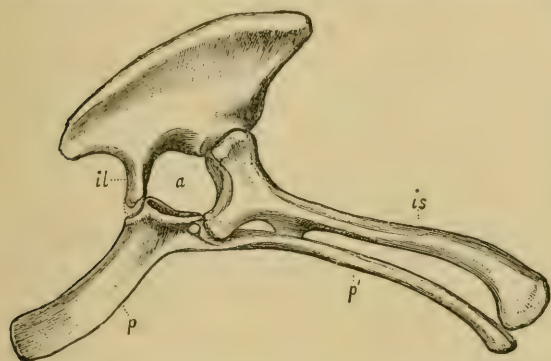


FIG 36.—PELVIC ARCH OF CAMPTOSAURUS (CAMPTONOTUS) *DISPAR* MARSH. No. 1878, YALE MUSEUM; SIDE VIEW; NAT. SIZE. *a*, ACETABULUM; *il.*, ILIUM; *is.*, ISCHIUM; *p*, PUBIS; *p'* POSTPUBIS. AFTER MARSH.

The femur has a long pendant third trochanter, and a prominent ridge to play between the tibia and fibula. The tibia is stout, and somewhat shorter than the femur. The fibula is slender, and shorter than the tibia. The astragulus and calcaneum are distinct. The second row of tarsals contains but two bones. The first digit in the pes was rudimentary, and did not reach the ground.

The second, third, and fourth were well developed. The fifth was entirely wanting. The number of phalanges, beginning with the first digit, was 2, 3, 4, 5. The structure of the hind limb and foot is well shown in Plate III, fig. 2, which is taken from the same skeleton as fig. 1.

Some of the principal measurements of the present species are as follows:

	<i>mm.</i>
United length of the nine cervical vertebræ.....	565
Length of axis.....	54
Transverse diameter of posterior articular face.....	41
Length of ninth cervical vertebra.....	64
Transverse diameter of posterior articular face.....	63
Length of humerus.....	337
Length of radius.....	245
Length of ulna.....	260
Length of femur.....	565
Length of tibia.....	555

The known remains of this species indicate an animal about 8 or 10 feet in height and herbivorous in habit. All the specimens discovered are from the *Atlantosaurus* beds of the Upper Jurassic.

Concerning the status of the material upon which the above genus and species was founded, Dr. R. S. Lull writes me as follows: "I find an old manuscript sheet in Marsh's writing in which No. 1877 is called the "type" of *C. dispar*. Professor Schuchert and I have decided therefore that 1877 should be the holotype and 1878 the paratype." No. 1877<sub>a</sub> may pertain to the holotype, but, as shown later, appears to represent a distinct individual.

While Marsh in the above description brings out most of the essential characteristics of this form, a recent examination of the type specimen, combined with a study of additional material, shows that several of the observations made at that time are not substantiated. These remarks apply particularly to the description and figures of the scapula and ilium, the latter, as will be shown later, being one of the most characteristic elements of the skeleton.

In a note published in the *American Naturalist*,<sup>a</sup> Dr. S. W. Williston first called attention to the perpetuation of an error by Mr. Richard Lydekker, who was struck with the great resemblance between the ilia (excepting the preacetabular portion) of *Camptosaurus dispar* and *Iguanodon dawsoni*. Doctor Williston says:

The fact is that the figure of the former is wrong. The anterior portion of the ilium of the type had been broken off and weathered, indications of which are distinctly seen in the specimen. Professor Marsh had this demonstrated to him more than five years ago, and there are other ilia in the Yale Museum in which this process is complete.

I quite agree with Doctor Williston's observations with the exception that none of the ilia in the Yale Museum, so far as I could find, show the complete preacetabular process, but there are other specimens in the collection which have considerably more of the process preserved than is shown in the ilium figured. That Marsh clearly recognized the incorrectness of his first figure is evident, since in a later paper<sup>b</sup> he republished a figure of the pelvic bones of *C. dispar* to the ilium of which had been added in outline a long, sharply-pointed anterior process. That he was still in error is clearly shown by the left ilium of *C. dispar*, Cat. No. 5473, U.S.N.M., which is terminated anteriorly by a somewhat rounded spatulate end (see fig. 29).

The incomplete scapula of the holotype was correctly figured on Plate \*3, fig. 1, in the original description, but later<sup>c</sup> the scapula and coracoid are represented as being complete. I am at a loss to understand, however, upon what evidence Marsh based this restoration of the upper free extremity of the scapula, which is so entirely different from all other scapulæ pertaining to the members of this genus. None of the ten or more scapulæ examined by me show anterior expansion of this end, but all agree, with slight variations, in having the same general contour as the scapula of No. 4282, seen in fig. 23. I dwell on the correctness of the contour of the type of *C. dispar*, from the fact that the specific characterization of *C. nanus* (see fig. 40) given by Marsh was based primarily upon the differences in contour displayed by the scapulæ of the two specimens discussed here.

<sup>a</sup> Amer. Nat., XXIV, 1890, pp. 472-473.

<sup>b</sup> Amer. Journ. Sci., XLIV, 1892, pl. v.

<sup>c</sup> Idem, XLVIII, 1894, pl. v.



*Detailed description.*—The skull and jaws of the holotype are unknown, and the complete neck with the first dorsal is all that is preserved of the vertebral column of this individual. The cervicals, posterior to the third, are all opisthocelous, the second and third, as in the other species of the genus, being plano-concave. The median ventral keel is wider and heavier, and the centra are not so deeply excavated laterally as in *C. browni*. The cervical region of the holotype of *C. medius* being still inclosed by the matrix, direct comparisons with that species could not be made.

The first dorsal, as in *C. browni*, is opisthocelous and shows the same transition of the parapophysis from the anterior end of the centrum in the ninth cervical to a position well up on the side of the neural arch on this vertebra. It is the first vertebra of the series to bear a true spinous process—a short spine 11 mm. high, slightly thickened and roughened at its upper extremity. The neuro-central sutures are plainly shown on all of the vertebræ preserved.

The sacrum, No. 1877a, Yale University Museum (see Plate 13), although considered by Marsh as pertaining to the holotype, in all probability belongs to another individual. This is shown by a comparison of the measurements of the cervical and sacral vertebræ with the homologous parts of Cat. No. 4282, U.S.N.M., the proper association of the different elements of this skeleton being unquestionable. Referring to the table of measurements on page 243, it will be seen that the cervicals are smaller and the sacrals larger than those of No. 4282. On account of the difference in proportions noted, I am inclined to believe the sacrum represents a distinct individual, and should, therefore, as it was included in the material first described, be considered a paratype, to which the catalogue number 1877a has been given to distinguish it from the holotype, No. 1877.

In the sacral region of No. 1877a there are five vertebræ united by suture, of which the posterior four represent true sacrals, or those which give support to sacral ribs. This interpretation excludes the anterior vertebra of the series which may be regarded as sacro-dorsal (a, Plate 13), as shown by the weak diapophyses which carried a single-headed rib. Marsh has described the peculiar peg-and-notch articulation (see 3, fig. 37) of the centra of this region and makes it an important feature of the genus, but after a study of several sacra I am inclined to believe too much stress has been laid on this character, as it appears to be a variable one. For example, in the sacrum of *C. browni* this peculiarity is only weakly developed between  $S_3$  and  $S_4$  (see fig. 17), and in *C. nanus* there is only the suggestion of such an articulation. In the sacrals under discussion this articulation is faintly shown between  $S_1$  and  $S_2$ , more pronounced between  $S_2$  and  $S_3$ , and strongly developed between  $S_3$  and

S<sub>4</sub> (see fig. 37). The ventral surfaces of all the centra are flattened, with a slight, median, longitudinal depression, which at once distinguishes them from the keeled or hamally rounded sacral centra of *C. browni*. The ventral surface of the sacro-dorsal is regularly and evenly rounded and is without the decided keel present in that of *C. browni*.

The two spinous processes preserved (see Plate 13) rise as thickened plate-like spines, the upper termination being thickened transversely, especially on the anterior part of this end. The spine of the sacro-dorsal is heavier anteriorly than the spine of sacral one, and probably indicates the culmination in the development of the spinous processes. The border below the thickened termination is compressed and presents a sharp anterior edge. The posterior border is somewhat thickened and has a shallow, vertical groove which may have received the sharp anterior edge of the spine posterior to

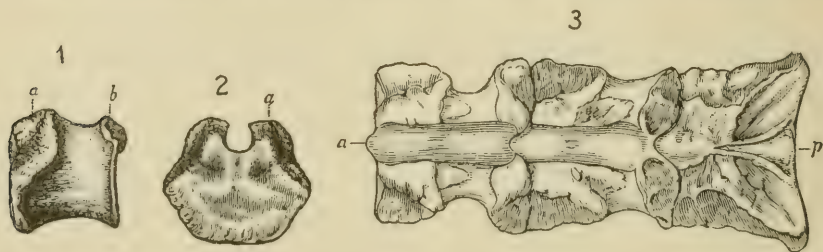


FIG. 37.—(1) LATERAL AND (2) FRONT VIEWS OF FIRST SACRAL CENTRUM CAMPTOSAURUS DISPAR MARSH. No. 1877a, YALE MUSEUM. PARATYPE.  $\frac{2}{3}$  NAT. SIZE. *a*, ANTERIOR FACE FOR ARTICULATION OF FIRST SACRAL RIB; *b*, POSTERIOR ARTICULATING SURFACE FOR SECOND SACRAL RIB. (3) POSTERIOR SACRAL VERTEBRÆ OF SAME.  $\frac{1}{2}$  NAT. SIZE. SHOWING PEG-AND-NOTCH ARTICULATION; TOP VIEW: *a*, ANTERIOR END; *p*, POSTERIOR END. AFTER MARSH.

it, which would give the plate-like appearance of the three median sacral spines, as shown by Marsh in his first restoration of *C. dispar*.

In No. 1878, Yale Museum, the ilium, pubis, and ischium are preserved, the two former elements being incomplete, that is, the ilium lacks most of the preacetabular and postacetabular processes, and the pubis most of the post-pubis, which, as shown in Plate 15, reproduced from a photograph of the specimens, has been restored in plaster.

In the pelvic bones are found the chief differences which serve to separate this species from the other members of the genus. The ilium, in proportion to its length, is considerably deeper and more robust than in any of the other species (compare figs. 29 and 30). The preacetabular notch is wide and the acetabular notch deep. The oblique border of the supero-posterior end is much longer—in most individuals a third longer than in *C. browni*—and terminates posteriorly as a thickened angular end.

The preacetabular process of this particular individual is unknown, and in the first figure of this element it was represented as being a very short, blunt process (see fig. 36). As previously stated, the first figures given are now known to be erroneous.

The shaft of the ischium of *C. dispar* is more robust, and at its distal termination has a larger hammer-like development of this end than is found in any of the known species (compare *Is.*, Plates 15 and 16), the greatest diameter being 106 mm. The pubis does not show any especial differences, while the post-pubis is almost wholly restored.

The limb and foot bones do not exhibit any especial characters except a more robust development than is found in the smaller species. It is at once distinguished from *C. amplus* by the greater size and the compressed, sauropod-like ungual of Digit I of the latter, as compared with the rounded, claw-like element of *C. dispar* (compare fig. 35 with fig. 38 and Plate 17).

Of the pes of No. 1877 I need mention only the extreme shortness of Metacarpal I as figured by Marsh. When compared with complete elements it appears that the upper third is missing, which would account for the extreme brevity of this digit as originally figured. In the same cut Digit III is represented as bearing the heaviest ungual, when, as shown by the pes of Cat. No. 4277, U.S.N.M. (see fig. 35), Digit II carries the most robust terminal phalanx of the hind foot. A cast of the foot in question now before me shows an ungual attached to the second digit whose small articular surface indicates at once that it has been wrongly placed, and in all probability pertains to Digit IV.

The manus, if correctly associated with the pes just discussed as pertaining to the same individual, shows variation from the same elements in Cat. No. 5473, U.S.N.M., being much lighter in construction, the hind feet having about the same dimensions. The association of the fore and hind feet of this latter individual is undoubtedly correct.

The fifth metacarpal is unusually short. The ungual of Digit III is very small, weak, and sharply pointed. Carpale five, as shown in the earlier figures of the manus of *C. dispar*, contributes to the articulating surface for the ulna and is so shown in the cast of the right fore foot. The unusual position of this element would hardly point to the true interpretation of the proper articulation of these bones, and it has been depicted otherwise, as shown in fig. 28. In the right foot I can only recognize seven carpal elements, although the eighth is probably fused with the radiale and Metacarpal I, and has thus lost its identity. Carpale three is almost wholly articulated with the proximal end of Metacarpal III. It is wedge-shaped, the thickened part being posterior. Carpale two occupies a posterior position



on Metacarpal II and is not visible from the front view as in the foot of Cat. No. 4277, U.S.N.M. (see fig. 28). In other respects the foot does not differ materially from the description already given in that part of the present paper devoted to the osteology of *Camptosaurus*.

The restoration (see Plate 18) of *Camptosaurus dispar* published by Marsh<sup>a</sup> was based on the typical specimens, and while it depicts well the general appearance of the animal, it is now known to be erroneous in the following particulars: The thoracic region is too long by at least three, and possibly five, vertebrae; all of the presacral vertebrae are rib-bearing, and thus there are no true lumbar; the anterior caudal vertebrae, as shown in the restoration, have the arches and transverse processes too high above the centra, the latter, as shown in fig. 18, being below the level of the pre- and postzygapophyses. The spines should also be more inclined backward and decrease more rapidly in height posteriorly; the transverse processes are continued too far posteriorly, as shown by two specimens in the National Museum, where they end on either the twelfth or thirteenth from the sacrum. Other minor corrections have been touched upon in the previous pages, so need no mention here.

As shown by the skeleton, *C. dispar* is an animal of quite robust proportions, only exceeded in size by *C. amplus*. Marsh estimated its length as being 20 feet.

After a review of the typical specimens as compared with the other species of the genus, *C. dispar* may now be distinguished by the following characters:

*Specific characters.*—Typically of large size. Cervical centra with heavy keel. Four sacrals with peg-and-notch articulation. Sacral centra flattened inferiorly. Sacro-dorsal without ventral keel. Ilium deep, and heavy in its proportions. Ischium stout, with greatly enlarged distal extremity. Ungual of Digit I of pes rounded and pointed.

#### CAMPTOSAURUS AMPLUS Marsh.

*Camptonotus amplus* MARSH, Amer. Journ. Sci. (3), XVIII, 1879, p. 503.

*Camptosaurus amplus* MARSH, Amer. Journ. Sci. (3), XXIX, 1885, p. 169; 16th Ann. Rep. U. S. Geol. Surv., 1894-95, Pt. 1, 1896, p. 196.

*Camptosaurus amplus* NOPCSA, Földtani Közlemény, Budapest, XXXI, 1901, p. 210.

*Camptosaurus amplus* HAY, Bull. No. 179, U. S. Geol. Surv., 1902, p. 501.

*Holotype.*—No. 1879, Yale University Museum, was collected by Mr. Arthur Lakes from "Big Canyon Quarry," Jurassic (Morrison Beds), in the vicinity of Como, Albany County, Wyoming. It consists of a right pes nearly entire. The first description is as follows:

A second species of this genus, about three times as large as the one [*C. dispar*] just described, is represented by various remains, among which is a left

<sup>a</sup> Amer. Journ. Sci., XLVII, 1894, pl. vi.

hind foot nearly entire. There were three functional digits in this foot, the first being rudimentary and the fifth entirely wanting. The metatarsal of the first digit is a splint, much curved, and with the apex above. The terminal phalanx of this digit is much compressed, not round as in the smaller species. The second metatarsal is of much greater length. The terminal phalanx of this digit is longer in proportion than that of the preceding species. The third and fourth digits were large and powerful. The main dimensions of this foot are as follows:

	mm.
Length of second metatarsal.....	295
Greatest diameter of proximal end.....	113
Length of third metatarsal.....	345
Greatest diameter of proximal end.....	150
Transverse diameter of distal end.....	102
Length of fourth metatarsal.....	305
Length of first phalanx of third digit.....	140
Length of first phalanx of second digit.....	120

The remains of the present species are from a lower horizon in the Jurassic than those described above, but within the limits of the Atlantosaurius beds.

An examination of the type specimen shows it to be a right instead of a left hind foot, as originally described, and it has been so re-mounted, as shown in Plate 17, reproduced here from a photograph.

As Marsh has already pointed out, *C. amplus* may be distinguished from the other species of the genus, (1) by its great size, (2) by the compressed terminal phalanx of the first digit. This phalanx, in nearly all of its details, resembles the ungual of the third digit of the pes in the opisthocelcian dinosaurs, as shown in fig. 38.

A second specimen, No. 1887, Yale Museum, consisting of portions of the skull and lower jaws (see Plates 7, 8, and 9), may, on account of its large size, be provisionally referred to this species. It was collected by Prof. O. C. Marsh from deposits in the Garden of the Gods, Colorado Springs, Colorado, in 1886. With this specimen was found the following note in Professor Marsh's handwriting: "Part of this animal and various Sauropoda bones were taken out by Professor Kerr in 1878." Diligent inquiry has failed to locate the repository of the parts of this specimen collected by Professor Kerr, but their association with Sauropoda remains would indicate the Jurassic age of the deposits in which they were originally found.

On page 1159 of volume 2 of Nicholson and Lydekker's Manual of Paleontology, they remark: "It is not improbable that the large Iguanodont from the Upper Jurassic of the United States, described as '*Camptosaurus amplus*,' should be referred to this group of *Iguanodon*, since it has but three functional digits in the pes."



FIG. 38.—UNGUAL OF FIRST DIGIT, CAMPTOSAURUS AMPLUS MARSH. No. 1879, YALE MUSEUM. HOLOTYPE.  $\frac{1}{2}$  NAT. SIZE. *a*, ARTICULAR END. ROUGH OUTLINE SKETCH SHOWING ITS SAUROPOD-LIKE SHAPE.

While the first digit in *C. amplus* is undoubtedly rudimentary, still it is at once distinguished from the remnant of the first metatarsal in *Iguanodon* by the heavy articular distal end of Metatarsal I, and the presence of two distal phalanges. The distal row of tarsals, as in *C. dispar*, consists of two elements (see Plate 17), although, comparatively speaking, somewhat reduced in size.

*Principal measurements of Specimen, No. 1879, Yale Museum.*

Digits.	I.	II.	III.	IV.
Greatest length of metatarsals.....	(a)	305	345	295
Greatest length of first row phalanges.....	66	117	124	84
Greatest length of second row phalanges.....	43	92	87	69
Greatest length of third row phalanges.....		103	60	44
Greatest length of fourth row phalanges.....			(b)	32

<sup>a</sup> Incomplete.

<sup>b</sup> Missing.

#### CAMPTOSAURUS MEDIUS Marsh.

*Camptosaurus medius* MARSH, Amer. Journ. Sci. (3), XLVIII, 1894, p. 85, pl. IV; 16th Ann. Rep. U. S. Geol. Surv., 1894-95, Pt. 1, 1896, p. 196, pl. LIII; Mon. Geol. Surv., XXVII, 1897, p. 502, text figs. 58, 59.

*Camptosaurus medius* NORCSA, Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Camptosaurus medius* HAY, Bull. No. 179, U. S. Geol. Surv., 1902, p. 501.

*Holotype*—No. 1880, Yale University Museum. This specimen was collected by Mr. W. H. Reed from "Quarry 13" in the Jurassic (Morrison beds) of Albany County, Wyoming.<sup>a</sup> It consists of a well-preserved disarticulated skull and jaws; 59 or more vertebrae, representing all parts of the vertebral column, of which at least half have the arches and spinous processes complete; two humeri, two ulnae, one radius, one femur, tibia and fibula, astragalus, calcaneum, left pes, two ilia, ischium, pubis, numerous ribs, and ossified tendons.

The species was never properly defined by Marsh, the original description consisting of the few lines which follow:

There are at least two small species of the genus (*C. medius* and *C. nanus*, noticed below). \* \* \* *C. medius* was about fifteen feet long. \* \* \* The skull, brain, and teeth of *C. medius* are shown on Pl. IV.

It is now known that the skull as figured<sup>b</sup> was reconstructed, not from the disarticulated elements of the holotype alone, but the nasal region and the lower posterior section of the skull and mandible were drawn from No. 1887, Yale Museum (see Plates 7 and 8), a very much larger individual which undoubtedly pertains to a distinct

<sup>a</sup> In his Bibliography and Catalogue of Fossil Vertebrata of North America Hay cites the occurrence of this species in Colorado. So far as known, it has not been found outside of Wyoming.

<sup>b</sup> 16th Ann. Rep. U. S. Geol. Surv., 1894-95, Pt. 1, 1896, pl. LIII.



species, as stated on page 277. Taking into consideration these facts in connection with many inconsistencies discovered in the figures, I do not believe that the skull, as illustrated, should be considered typical of the species. The teeth, as shown in fig. 9, are of the holotype, but I am unable to find that they show any distinctive characters. While the skull may show specific differences when the crania of the other forms are known, such comparisons can not be made at present, owing to the lack of material.

The parts of the type-specimen, as enumerated above, represent a considerable portion of the entire skeleton, and it is unfortunate that they have not yet been made ready for study. At present only the disarticulated elements of the skull and jaws, limb, foot, and pelvic bones (see Plate 16) have been freed from the matrix, the other parts being still largely enveloped in the hard, concretionary mass in which they were originally entombed.

Even though Marsh failed to define this form, I believe it to represent a valid species intermediate in structure between *C. dispar* and *C. browni*. From *C. dispar* (compare Plates 15 and 16), its nearest ally, it may be distinguished by the lighter structure of the pelvic bones, that is, the ilium is considerably narrower in proportion to its length. The oblique border of the supero-posterior end is somewhat shorter. The ischium is much more slender, and the hammer-like expansion of the free end less robust, its greatest diameter measuring 73 mm. Throughout the skeleton of *C. medius* appears to be lighter and more delicately constructed. The femur pertaining to the type-specimen is proportionately very short, but I am inclined to the opinion that this is either due to severe crushing, or the preparator, in joining the two ends, has omitted a section of the shaft of the bone, which would account for the extreme brevity of this element.

Except in its smaller size, the hind foot shows no essential differences when compared with that of *C. dispar*. The following are the measurements of the left pes of No. 1880:

	mm.
Greatest length of metatarsal I.....	74
Greatest length of metatarsal II.....	148
Greatest length of metatarsal III.....	181
Greatest length of metatarsal IV.....	151

It is anticipated that upon the complete preparation of the type material, characters will be disclosed by which this species may be more completely defined, but for the present it must rest on those shown by the pelvis, although the dissimilarity shown by these bones certainly suggests other and even more important differences in the other portions of the skeleton.

## CAMPTOSAURUS NANUS Marsh.

*Camptosaurus nanus* MARSH, Amer. Journ. Sci. (3), XLVIII, 1894, p. 85, pl. v., fig. 3; 16th Ann. Rep. U. S. Geol. Surv., 1894-95, Pt. 1, 1896, p. 196, pl. LV, fig. 2.

*Camptosaurus nanus* WALCOTT, Science (2), XI, 1900, p. 23.

*Camptosaurus nanus* NOPCSA, Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Camptosaurus nanus* HAY, Bull. No. 179, U. S. Geol. Surv., 1902, p. 501.

*Holotype*.—Cat. No. 2210 U.S.N.M.<sup>a</sup> was collected by Mr. W. H. Reed from the upper Jurassic (Morrison beds), "quarry 13," near Como, Albany County, Wyoming,<sup>b</sup> in 1882.

The elements preserved are as follows: Portion of atlas, axis, 7 cervical, 16 dorsal, 4 sacral, and 3½ caudal vertebrae, numerous cervical and thoracic ribs, right fore limb (scapula, coracoid, humerus, radius, and ulna), 2 femora, 2 tibiae, left fibula, 2 ilia, 2 ischia, portion of left pubis, 2 metacarpals, 1 carpal, and parts of ossified tendons.

The original description is as follows:

The smallest species of the genus *C. nanus* was not more than 6 feet in length, and perhaps 4 feet in height when standing at rest. One of the striking features of this diminutive species is its long sigmoid scapula, shown in fig. 3, Plate V. This is in strong contrast with the short, straight scapula of *C. dispar*, seen on the same plate, fig. 2.

*Detailed description*.—The cervical vertebrae of the present species, as compared with the corresponding parts of the larger forms, show no particular distinguishing characters, although they differ in minor details.

The entire neck and the first two dorsals remain articulated, and thus the true relationship of these parts is accurately displayed. The neck shows the same graceful upward curve of the cervicals as is found in the related species. The transition of the parapophyses from the anterior lateral border of the centrum of the ninth cervical to the elevated position on the side of the neural arch on the tenth (considered the first dorsal), agrees with the conditions found in *C. browni* and in the holotype of *C. dispar*.

The odontoid is all that remains of the atlas. The axis, which lacks a portion of the spinous process, is otherwise very similar to the same bone in *C. dispar*. The second, or axis intercentrum, is not co-ossified as in the other species. In the narrowness of the ventral keel and the deep lateral depressions on the sides of the centra the remaining cervicals appear to approach the vertebrae of *C. browni*.

<sup>a</sup> Marsh's original accession number is [1561]. No. 1881 is the number under which this specimen was catalogued while in the Yale University Museum.

<sup>b</sup> Bull. No. 179, U. S. Geol. Surv., p. 501. Hay gives the locality as Wyoming (?). On the original field labels found with the specimens the locality was given in full, and may now be considered as absolutely determined.

rather than those of *C. dispar*. The opisthocoelean nature of the anterior vertebrae is not so pronounced as in the larger species.

The dorsal series, though all are not articulated, appears to be complete, consisting of 16 vertebrae, many of which lack parts of their processes. The only marked characters in the dorsals of *C. nanus* are to be seen in the spinous processes of the posterior portion of the series, which are comparatively thin and lack the enlarged upper extremities of the same vertebrae in *C. dispar* and *C. browni*. The arches also appear to be relatively higher, with a corresponding enlargement of the neural canal, in this respect approaching *C. prestwichii*. The sides of the centra (considered as a whole) are less concave in the longitudinal direction and appear to be more evenly rounded ventrally. The centra gradually increase in length from the first to the thirteenth, the fourteenth being the shortest of the posterior dorsals (26 mm.). The fifteenth and sixteenth dorsals may be distinguished from the others by the enlargement of their posterior ends in adaptation to the corresponding surfaces of the centra with which they articulate. The sixteenth or sacro-dorsal (see *S. dor.*, fig. 39) is suturally united with the centrum of the first sacral. Its ventral surface lacks the decided

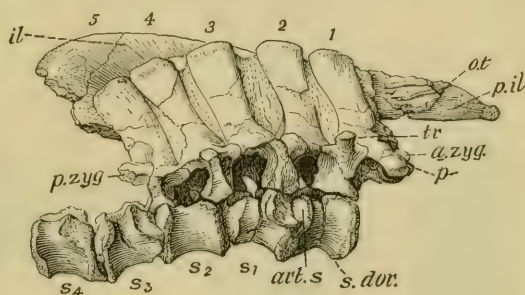


FIG. 39.—SACRUM OF CAMPTOSAURUS NANUS MARSH. CAT. NO. 2210, U.S.N.M.  $\frac{1}{3}$  NAT. SIZE. HOLOTYPE. VIEWED FROM THE RIGHT SIDE. *a. zyg.*, PREZYGAPOPHYSES; *art. s.*, ARTICULAR SURFACE FOR FIRST SACRAL RIB; *il.*, ILIUM; *o. t.*, OSSIFIED TENDONS; *p.*, PARAPOPHYSIS OF THE FIFTEENTH DORSAL; *p. il.*, PREACETABULAR PROCESS OF ILIUM; *p. zyg.*, POSTZYGAPOPHYSES; *S<sup>1</sup>*, *S<sup>2</sup>*, *S<sup>3</sup>*, *S<sup>4</sup>*, SACRALS ONE TO FOUR, RESPECTIVELY; *tr.*, TRANSVERSE PROCESS OR DIAPOPHYSIS; *1*, SPINE OF FIFTEENTH DORSAL; *2*, SPINE OF SIXTEENTH OR SACRO-DORSAL; *3*, *4*, AND *5*, SPINES OF SACRALS ONE, TWO, AND THREE.

keel found in the sacro-dorsal of *C. browni*. The more detailed description of this vertebrae and the succeeding sacrals will be found in that part of the present paper relating to the osteology of *Camptosaurus*, pages 242 to 244. The sacral vertebrae show the most distinctive character of the species in the absence of the peculiar peg-and-notch articulation of the centra, which forms an important feature of the larger species. By some this difference might be considered of more than specific importance, but on account of the close similarity (except in size) of nearly all of the other elements to the homologous parts of the larger species, and the lack of other diagnostic characters, I can see no reason for separating this form generically. It is of interest to note the similarity in this respect of *C. nanus* to *C. prestwichii* as described and figured by Hulke (see fig. 43).



Most of the caudal vertebrae are articulated, the first alone of the anterior ones being detached, but its size and other characteristics at once show its proper place in the series. So closely do they resemble the caudals of *C. browni*, described elsewhere, that I shall mention only a few of their important features.

The second caudal bears the first chevron. As in *C. browni*, transverse processes are developed on the first thirteen vertebrae, counting back from the last sacral, where they stop abruptly. As shown by some of the detached transverse processes, they are united to the vertebrae by suture, about equally with the upper lateral surface of the centrum and the lower lateral surface of the pedicle of the neural arch. This would appear to indicate ossification from a separate center and would also suggest the appropriateness of calling them caudal ribs, as is done by some anatomists. A distal caudal preserved exhibits the usual long, slender, pre- and postzygapophyses. The important measurements of the vertebrae will be found in the table on pages 242 to 244.

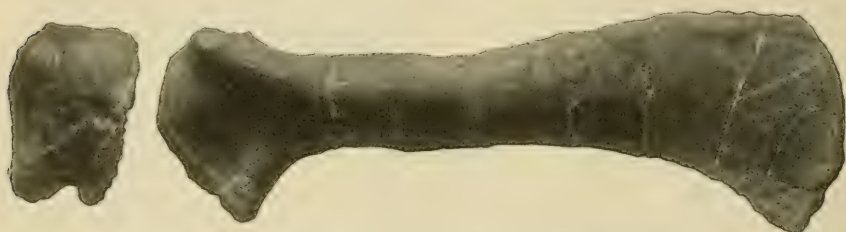


FIG. 40.—RIGHT SCAPULA AND CORACOID (REVERSED) OF CAMPTOSAURUS NANUS MARSH. CAT. NO. 2210, U.S.N.M. HOLOTYPE.  $\frac{1}{2}$  NAT. SIZE. FROM A PHOTOGRAPH.

The right fore limb, lacking most of the foot, is preserved with this specimen, and is the one on which Marsh based his restoration of the limb of *C. nanus*, first published<sup>a</sup> in July, 1894, the foot there shown being drawn after that of *C. dispar*, No. 1877, Yale Museum.

The scapula, as will be observed by comparing it with the same elements of the larger species (as shown in fig. 23), shows no appreciable differences, except in its much smaller size. Thus, as will be seen, *C. nanus* can not be distinguished by its "long sigmoid scapula," as first defined by Marsh, he being led into this error by a wrong interpretation of the missing upper part of the scapula of the typical specimen of *C. dispar*, of which he attempted a restoration at the time of describing the present species.

The coracoid, as compared with the same element of *C. dispar* and *C. browni*, is shorter antero-posteriorly, more quadrangular in outline, with a proportionately deeper notch on the inferior border.

The foramen is not closed, as represented in Marsh's figure, but, as in the other forms, is a notch, being open to the articular border for

<sup>a</sup>Amer. Jour. Sci., XLVII, pl. 5, fig. 3.

the scapula. In the type-specimen the coracoid and scapula were not coossified. (See fig. 40.)

The humerus lacks the robust development of the deltoid crest and the articular ends are not so rugose as in the larger species; in other respects they appear identical (compare figs. 25, 26, and 41).

The ulna (see *ul.* fig. 41) appears to be more curved than the ulnæ of either *C. browni* or *C. dispar*, but in the triangular contour of the proximal end it approaches the latter species. The radius shows no important differences.

Both of the ilia were recovered and, as found, were not far removed from their normal position in relation to the sacrum, as shown in fig. 39, the left one being the more complete. In its general proportions it approaches the ilium of *C. dispar* (see Plate 14, fig. 2) rather than the narrow and more depressed ilia of either *C. medius*, *C. browni*, or *C. depressus*, although the anterior termination of the preacetabular process is especially like that of the latter species. The acetabular notch is deep and the ischiac process robustly developed, and there is a wide horizontal plate or shelf on the inner side of the posterior portion, as in the larger species. The pubic process is directed forward and well downward, thus giving good width to the preacetabular notch.

The ischia of *C. nanus* lack their distal ends, but a comparison of the remaining parts with those of the larger species shows no especial differences. The portion of a pubis pertaining to the type is too mutilated to allow of accurate comparison, although it shows that a postpubic process was present.

Except in their very much smaller size, a critical comparison of the elements of the hind limbs of *C. nanus* with those of *C. dispar* failed to reveal any essential differences. Ossified tendons still adhering to the vertebræ, and particularly to the sacrum, were found in the matrix (see *q. t.*, fig. 39).

After a careful review of the typical material, as compared with the other species of this genus, I find that *C. nanus* may now be characterized as follows:

*Specific characters.*—Typically of small size. Coracoid short, quadrangular in outline. Sacral vertebræ without peg-and-notch articulation.



FIG. 41.—RIGHT HUMERUS, RADIUS AND ULNA CAMPTOSAURUS NANUS MARSH. CAT. NO. 2210, U.S.N.M. HOLOTYPE.  $\frac{1}{2}$  NAT. SIZE. *h*, HUMERUS; *ra*, RADIUS; *ul*, ULNA. FROM A PHOTOGRAPH.

That the type-specimen represents an adult individual there appears to be but little question. While the sutures on the vertebrae are plainly discernable, nearly all of the arches remain attached to their centra, while in some of the larger species we find them wholly



FIG. 42.—(1) RIGHT FEMUR CAMPTOSAURUS NANUS MARSH. CAT. NO. 2210, U.S.N.M. HOLOTYPE.  $\frac{1}{2}$  NAT. SIZE. INTERNAL VIEW. (2) FRONT VIEW OF SAME. *a*, LESSER TROCHANTER; *b*, INNER TROCHANTER; *h*, HEAD. FROM A PHOTOGRAPH.

detached. If a young individual, it is of interest to note the presence of ossified tendons in an immature animal, a condition hardly to be expected.



*Principal measurements of Camptosaurus nanus.*

	mm.
Greatest length of left ilium.....	244
Greatest vertical height over ischiac process.....	82
Greatest vertical height over pubic process.....	77
Greatest vertical height middle of acetabulum.....	45
Combined length of four sacral centra.....	126
Greatest length of femur.....	258
Greatest width of proximal end of femur.....	72
Greatest width of distal end of femur.....	71
Greatest length of tibia.....	235
Greatest width of proximal end of tibia.....	83
Greatest width of distal end of tibia.....	79
Greatest length of fibula.....	207
Greatest width of proximal end of fibula.....	47
Greatest width of distal end of fibula.....	26
Greatest length of scapula.....	187
Greatest width of articular end.....	53
Greatest width of free end.....	59
Greatest length of coracoid.....	35
Greatest width of coracoid.....	49
Greatest length of humerus.....	143
Greatest width of proximal end of humerus.....	43
Greatest width of distal end of humerus.....	30
Greatest length of ulna.....	102
Greatest width of proximal end of ulna.....	26
Greatest width of distal end of ulna.....	21
Greatest length of radius.....	45
Greatest width of proximal end of radius.....	16
Greatest width of distal end of radius.....	15

Measurements of the vertebræ of this specimen will be found in the table of comparative measurements given on pages 242 to 244.

## CAMPTOSAURUS PRESTWICHII (Hulke).

*Iguanodon prestwichii* HULKE, Quart. Journ. Geol. Soc. London, XXXVI, 1880, pp. 433-454, pls. XVIII-XX, figs. 3-5.

*Cumnoria prestwichii* SEELEY, Rep. Brit. Ass. for 1887 (1888), p. 698.

*Camptosaurus prestwichii* LYDEKKER, Cat. Foss. Reptilia and Amphibia Brit. Mus., Pt. 4, Suppl., 1890, p. 259; Quart. Journ. Geol. Soc. London, XLV, 1899, pp. 47, 48.

*Camptosaurus prestwichii* NOPCSA, Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Holotype*.—Preserved in the Museum at Oxford, England; collected from the Kimeridge Clay of Cumnor-Hurst, Oxfordshire, England. Consists of a fairly complete skeleton, of which the following elements are preserved: Parts of the posterior region of the skull, portions of the parietals, frontals, and postfrontals, both mandibular rami, portions of both maxillæ; 64 centra, of which 7 are considered cervical, 18 dorsal, 4 sacral, and 35 caudal; portions of both ilia, fragments of the pubes, and 1 ischium. The limbs are repre-

sented by the articular ends of the femora, tibiæ, and fibulæ; tarsals, metatarsals, and phalanges; portions of the scapulæ, humeri, and metacarpals.

In the original paper, Hulke gives a detailed description of the skeletal parts of the holotype. The article in question is of too great length, however, to be wholly incorporated in the present paper, and I shall confine my remarks to a brief review of the chief characteristics, as described and figured by Hulke, in comparison with those of the American species.

*Review of the typical material.*—The occipital condyle has the same reniform outline and forward development of the articular area on the ventral surface as found in the American species. Its union with the basisphenoid by a median tongue of bone received in a corresponding notch on the posterior end of the latter element, and the pronounced winding grooves on the lower and lateral surfaces of the basisphenoid which marks the course of the internal carotid artery, are similar to those in *C. dispar*. The exoccipitals are perforated by the usual foramina, and, as in *C. dispar*, these bones enter slightly into the formation of the occipital condyle. The supra-occipital contributes to the upper boundary of the foramen magnum, its outline and relationship to the surrounding elements appearing identical with the same bone in *C. dispar*, as shown in fig. 4. The parietal bone is single, the median crest sharper than in either *C. medius* or *C. dispar*. The frontals are short and broad, and but little, if any, of their outer borders enter into the formation of the orbital cavity. The post-frontal has a smooth orbital surface of great extent. I am unable to detect any differences which would distinguish the teeth of the upper and lower jaws from those of the American forms. An idea of their size may be gleaned from the following measurements: In a piece of the maxillary, in a space of 75 mm., are the sockets of an outer series of nine teeth. The breadth (that is, antero-posterior dimension) of a fully formed upper crown is 9.5 mm. The greatest breadth of the largest lower tooth crown is 12.5 mm., that of other crowns varying between 10 and 11.5 mm.

Of the twenty-five presacral vertebræ preserved, seven are considered by Hulke as cervical, and, since the atlas and axis are missing, there would be in the complete neck at least nine vertebræ. The opisthocœlous nature of the centra, the presence of the parapophyses on the anterior end of the centra, the deep, lateral depression, and the pronounced median keel, are all characters common to the other members of the genus. But the angularity of the centra, as viewed from the end, is peculiar to this species.

In the anterior dorsals it is apparent from Hulke's description that the transition of the parapophyses from the centrum in the

last cervical to the side of the neurapophyses in the early dorsals, and finally to the anterior border of the transverse process in the median dorsal region, approximates the conditions noted in the American species. The presence of 18 dorsals with this specimen raises the question as to the correctness of the vertebral formula of *Camptosaurus*, as determined from a study of the two skeletons, Cat. Nos. 4282 and 2210, U.S.N.M., which agree in having 16 vertebrae, considered as dorsals, in front of the sacrum. If 16 is the correct number for *Camptosaurus*, then *C. prestwichii*, having 18 dorso-lumbar, approaches *Iguano-*  
*don* more closely.

In the sacrum, five vertebrae are united by suture, the most anterior of which is considered by Hulke as a lumbar (sacro-dorsal), the posterior four being true sacrals (see fig. 43). While the sacrals do not show the well-defined peg-and-notch articulation of some of the American species, yet, as shown by the figures of this region, there appears to be a tendency toward the development of such an articulation between sacrals one and two, and also between sacrals two and three, much as in *C. nanus*. In the size and number (five) of coossified vertebrae and the contour of their ventral surfaces, the sacrum approaches that of *C. nanus*. It differs, how-

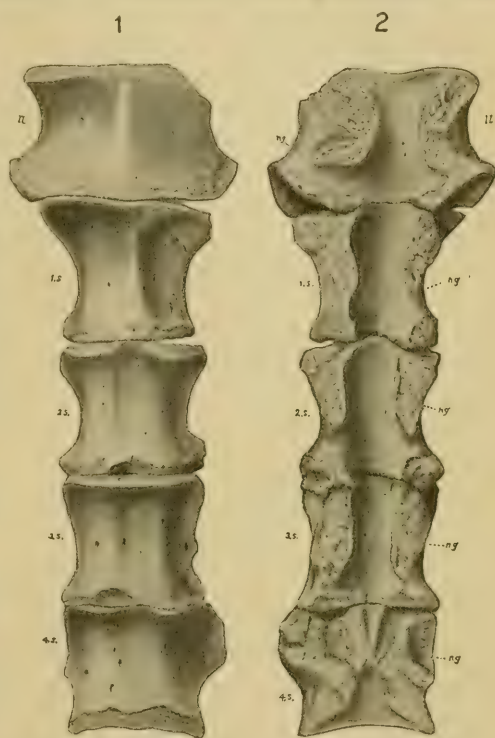


FIG. 43.—(1) THE LAST DORSAL OR SACRO-DORSAL AND SACRUM OF CAMPTOSAURUS PRESTWICHII (LYDEKKER), MUSEUM OF OXFORD. HOLOTYPE. SEEN FROM BELOW.  $\frac{1}{3}$  NAT. SIZE. (2) THE SAME FROM ABOVE; ll, SACRO-DORSAL; 1. s., 2. s., 3. s., AND 4. s., SACRALS ONE TO FOUR, RESPECTIVELY; ng, NERVE-GROOVE. AFTER HULKE.

ever, in the transversely contracted neural canal of the fourth which also bears the transverse process or last sacral rib wholly upon its centrum. As will be seen in fig. 39, this rib is borne intervertebrally in *C. nanus*. In the transverse contraction of the neural canal of *C. prestwichii*, the fourth sacral resembles that of *C. dispar*, as shown in fig. 37, although, as in *C. nanus*, the rib is supported intervertebrally.



The anterior caudal vertebrae, as described, show the same shortness of centrum, the backward slant of the spinous process, the transverse processes, and the distinctive obliquity of the more anterior ones. As in the American species, the suppression of the transverse processes is soon followed by the disappearance of the neuro-central suture. The median caudals are compressed and the more distal ones have a simple, cylindrical form.

The change in form of the articular surfaces of the vertebral centra, traceable through the column, when compared with the American species, is highly instructive. In the neck these surfaces are opisthocœlous; at the root of the neck, the anterior ball is less convex, the posterior cup less deep; in the forward dorsal region, the anterior surface is very slightly concave, the posterior surface more so, and in the tail, both surfaces are concave.

Such parts of the ilia as are preserved apparently lack the horizontal plate developed in all of the American species. Its absence, however, may be due to the mutilated condition of the bones. The pubis and ischium were too fragmentary for description.

The femora were represented by portions of the articular ends. The presence of a deep, narrow, anterior intercondylar notch characteristic of the Wealden iguanodonts, is quite different from the broad, comparatively shallow groove found on the femora of *Camptosaurus*. The tibiae, which are also imperfect, show no important differences.

The tarsus consists of two elements, astragalus and calcaneum, which, as in the American species, remain distinct, and appear quite similar in nearly all respects. There were no elements found which could be identified as pertaining to the distal row of the tarsus.

As described, the foot elements show no particular differences from the American species, except in the lateral compression of the unguals, those of the American species, with the exception of the first, being somewhat depressed.

Some imperfect bones, which were more slender and appeared to have been relatively longer than the metatarsals. Hulke regarded as metacarpals. These are suggestive of an iguanodont rather than a camptosaurian type of animal.

The other elements preserved are all too fragmentary to admit of comparison.

The specimen, as briefly reviewed above, was first described by Hulke as a new species of *Iguanodon*, being separated from its nearest ally, *I. mantelli*, by the following characters: "The flattening of the undersurface of the sacral centra, and the relative simplicity of the marginal serrature of its teeth." Later, Seeley proposed the genus *Cumnoria* for the reception of this fossil, characterizing it as follows: "It is separated from *Iguanodon* by many characters, such as the

different type of the parallel ridging and coarser serration of the teeth. The vertebrae are relatively wider, the neural arch and centrum both being more depressed; the lamina of the neural arch are very stout, and the neural canal very small; the sacral vertebrae are not ankylosed, are only four in number, and are convex on the ventral surface. The early caudal vertebrae are reduced in length, and have the neural arch small. The astragalus and calcaneum are separate."

In 1899, Lydekker referred the species to *Camptosaurus*, thus relegating *Cumnoria* "to the rank of a synonym till it can be shown to have well-marked distinctive features." He further says: "Evidence of affinity between that species [*Cumnoria* (*Iguanodon*) *prestwichii*] and *Camptosaurus* is shown by the angulated and flattened haemal surface of the sacral vertebrae, and by the absence of ankylosis between the centra."

Hulke believed the typical specimen to represent an animal between 10 and 12 feet in length, but not fully adult.

While the foregoing review of the description and figures of *C. prestwichii*, as compared with the homologous parts of the American species, show many points of resemblance, certain differences which have been pointed out show a closer relationship to *Iguanodon* than to *Camptosaurus*. The acquisition of better-preserved specimens may eventually show the generic distinctness of this form; but at the present time I fail to detect characters of sufficient importance to warrant its separation. For the present, *C. prestwichii* may be distinguished as follows:

*Specific characters*.—Typically of moderate size; centra of cervical vertebrae subrhombic in outline. Sacrum of four vertebrae without peg-and-notch articulation. Femur with deep, narrow, intercondylar notch. Unguals of pes compressed laterally. Metacarpals slender and relatively longer than metatarsals.

#### CAMPTOSAURUS? LEEDSI Lydekker.

*Camptosaurus leedsi* LYDEKKER, Quart. Journ. Geol. Soc. London, XLV, 1889, pp. 46-48, fig. 3.

*Camptosaurus leedsi* NOPCSA, Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Holotype*.—A fairly complete femur from the left side, now preserved in the collection of Mr. A. N. Leeds, of Eyebury, England. From the Oxford Clay, near Peterborough, England.

*Description*.—No characters of specific importance were given by Lydekker to separate this species from the other forms under this genus. For the present I can do no better than to quote Mr. Lydekker's original comments.

The present middle portion of the shaft has been considerably crushed and broken, but both extremities are entire. The shaft agrees with the femur of

*Hypsilophodon* and of the North American *Camptosaurus* (*Camptonotus*), and differs from that of *Iguanodon* in its markedly forward arcuation. The inner trochanter has lost its free extremity, but the basal portion shows that it is of the "pendant" type characteristic of the two former genera and not the "crested" type found in *Iguanodon*. The anterior intercondylar groove is slightly less developed in this specimen than in either of the Wealden genera, but it is still present. \* \* \* There is, indeed, no decisive evidence to prove that the present specimen indicates a form specifically distinct from the species from the Kimeridge Clay [*C. (Iguanodon) prestwichii*]; but since most of the

Sauropterygians of the Kimeridge are distinct from those of the Oxford Clay, I think it highly probable that the same may hold good with the Dinosaurs, and I therefore propose to provisionally regard the present specimen as the representative of a distinct species which may have been somewhat smaller than *Iguanodon prestwichii*, \* \* \* and since I can see no characters by which either this specimen or *I. prestwichii* can be separated from *Camptosaurus*, I propose to refer both the Kimeridgian and Oxfordian species to that genus under the respective names of *C. prestwichii* and *C. leedsi*.

While the femur of *C. leedsi*, as described and figured by Lydekker, appears similar in most respects to the femora of the American *Camptosaurus*, yet the position of the inner trochanter wholly upon the proximal half of the shaft (see fig. 44) at once distinguishes it from all of the described species of that genus, which in all cases show this trochanter extending somewhat below the median line. That *C. leedsi* represents a closely related form there can be no question, but, if referable at all to an American genus, its closest affinities, as indicated by the femur, are with *Dryosaurus*. This suggestion becomes more apparent when it is known that a recent examination of the type specimen of *D. altus*, No. 1876, Yale Museum, shows that the femur has been

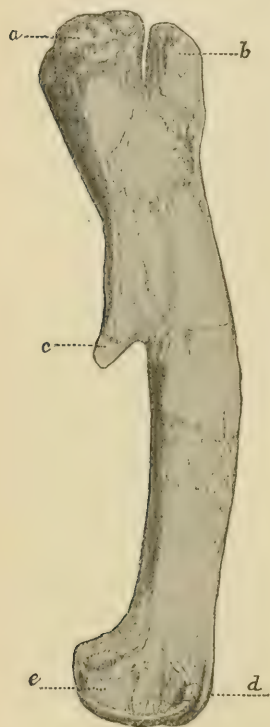


FIG. 44.—LEFT FEMUR OF CAMPTOSAURUS LEEDSI LYDEKKER; FROM THE OXFORD CLAY NEAR PETERBOROUGH.  $\frac{1}{3}$  NAT. SIZE. HOLOTYPE. a, HEAD; b, LESSER TROCHANTER; c, INNER TROCHANTER; d, INTERCONDYLAR GROOVE; e, INNER CONDYLE. AFTER LYDEKKER.

incorrectly illustrated. For example, the shaft is not straight, but is curved as in *Camptosaurus*, and while the inner trochanter is upon the proximal half, it is not placed so high as indicated in the figure.<sup>a</sup> The femur of *C. leedsi* may be distinguished from the femur of *Hypsilophodon* by the "more wing-like" shape of the inner trochanter of the former.

<sup>a</sup>Amer. Journ. Sci., XVI, 1878, pl. ix, fig. 3.



## CAMPTOSAURUS? VALDENSIS Lydekker.

*Hypsilophodon* LYDEKKER, Cat. Foss. Reptilia and Amphibia. Brit. Mus., Pt. 1, 1888, pp. 195, 227; Geol. Mag., Dec. 3, V, 1888, p. 453.

*Camptosaurus valdensis* LYDEKKER, Quart. Journ. Geol. Soc. London, XLV, 1880, p. 48.

*Camptosaurus valdensis* NOPCSA, Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Holotype*.—No. R. 167, British Museum; an imperfect femur, from the Wealden of the Isle of Wight. With this Lydekker provisionally associates a mandibular ramus, No. R. 180.

Lydekker<sup>a</sup> records this femur as pertaining to the genus *Hypsilophodon*. Later he says:

It is not improbable that the mandibular ramus entered on p. 227, Cat. of Fossil Reptilia and Amphibia of the British Museum, as a young *Iguanodont*, may really indicate a smaller adult form, allied to *Laosaurus* or *Camptosaurus*, in which event the undetermined femur mentioned on p. 195 may perhaps belong to the same form.

A year later he comes to the following conclusion regarding the disposition of these specimens:

I have called attention to an imperfect femur in the British Museum (No. R. 167) from the Wealden of the Isle of Wight, which has been referred to *Hypsilophodon*, and have suggested that, together with a mandibular ramus (No. R. 180) from the Wealden, hitherto regarded as that of a young *Iguanodon*, it probably indicates a form allied to *Camptosaurus*. A comparison of this femur with the subject of the present communication [*C. leedsi*], shows such a close similarity between the two that there is every probability of their generic identity; and since there is no other evidence of the existence of a *Hypsilophodon* of these dimensions, I propose to apply the name *Camptosaurus valdensis* to the Wealden form, of which I take the femur as the type, and provisionally associate with it the mandibular ramus.

Since the type femur has not been described nor figured, a comparison with the femora of American forms can not be made at this time, but, inasmuch as its resemblance to the typical femur of *C. leedsi* was the chief reason for assigning it to this genus, there is every probability that this form is also distinct from *Camptosaurus*. The fragmentary nature of the material upon which the species is based precludes the possibility of ever defining it adequately, and it will probably always remain a species of uncertain affinities.

## CAMPTOSAURUS? INKEYI Nopcsa.

*Camptosaurus inkeyi* NOPCSA, Denkschr. k. k. Akad. Wien, LXVIII, 1899 (1900), p. 579; Földtani Közlöny, Budapest, XXXI, 1901, p. 210.

*Holotype*.—Dentary and a fragment of the angular from the Upper Cretaceous of Transylvania (Comitat Hunyad), Hungary.

<sup>a</sup> Catalogue of Fossil Reptilia and Amphibia in the British Museum, p. 195.

The original preliminary description of this species, which appears as a footnote in Nopcea's paper on *Limnosaurus transsylvanicus* in the publication cited above, is as follows:

*Camptosaurus inkeyi* new spec. (nach Herrn Béla Inkey ehemaligen Chef-geologen der k. ung. geol. Anstalt als Zeichen meiner Dankbarkeit für die zahlreichen Winke, durch die er mir das Studium der geologischen Verhältnisse des Hätzszegethales wesentlich erleichterte). Nur Dentale und ein Fragment der Angulare erhalten. Partie bei der Symphyse dreikantig und auf spitzen Schnabel hinweisend. Keine eigene Symphysenfläche, sondern die Kieferspitze innen und aussen rauh sculpirt, was auf ligamentöse Verbindung deutet. Foramen mentale vorhanden. Eine darüber gelegene Rinne (wie bei den *Iguanodontiden*) fehlt. Ober- und Unterrand des Kiefers nicht parallel. Unterrand etwas gekrümmt wie bei *Hypsilophodon* (Hulke 1882). Innerand bei den Alveolen gleich hoch mit dem Aussenrand. Die interne Rinne und die Foramina (10) sehr stark entwickelt. 10 Alveolen. Zähne ähnlich wie bei *Camptosaurus*, jedoch regelmässiger gekerbt. Ohne bemerkenswerthen Mediankiel. Eine detaillirtere Beschreibung soll bei einer anderen Gelegenheit gegeben werden.

From the above description it is at once apparent that the dentary of *Camptosaurus inkeyi* is quite unlike those of the American species, so far as known. In *C. dispar*, as shown in fig. 8, the outer and inner surfaces of the anterior end of the dentary are reasonably smooth; the upper and lower borders parallel, the ventral nearly straight, curved slightly if at all; internal alveolar border lower than external; fifteen to sixteen alveoli; teeth with one or more prominent and many secondary longitudinal ridges. A comparison of these characters with those described by Nopcea shows but few in common. These appear to be in the presence of the foramen mentale, the curved teeth, and the presence of a longitudinal groove below the internal alveolar border pierced by the foramina, the latter, however, being more numerous in the American species.

The wide differences shown in the above brief review appear to indicate at least the generic distinction of the form under consideration, but since Nopcea has promised a more detailed description of his specimen, I shall leave the matter to him for final disposition.

CAMPTOSAURUS DEPRESSUS, new species.

*Camptosaurus* LUCAS, Proc. U. S. Nat. Mus., XXIII, No. 1224, p. 591.

*Holotype*.—Cat. No. 4753, U.S.N.M. Collected by Mr. N. H. Darton, of the U. S. Geological Survey, in "Calico Canyon," near Buffalo Gap Station, South Dakota, from beds considered by him to be of Lower Cretaceous age (Lakota sandstone).

The type specimen consists of portions of both ilia, anterior part of the blade of one pubis, an incomplete sacrum, centrum of the last or sacro-dorsal, 12 caudal vertebrae, 1 thoracic rib, and many fragments. This specimen was associated with the fragmentary skeleton, No. 4752, U.S.N.M., described by Dr. F. A. Lucas as *Stegosaurus*

*marshii*<sup>a</sup> and later referred by him to the new genus *Hoplitosaurus*.<sup>b</sup> Most of the elements preserved were inclosed in two large pieces of rock.

The distinctive characters shown by the ilia, sacrum, and pubis appear to justify the establishing of a new species, for which I propose the name *Camptosaurus depressus*, the specific name being suggested by the narrowness or depressed nature of the ilia.

*Specific characters.*—*Ilium narrow with shallow acetabular and*



FIG. 45.—ANTERIOR PORTION OF RIGHT ILIUM OF CAMPTOSAURUS DEPRESSUS. CAT. No. 4753, U.S.N.M. HOLOTYPE.  $\frac{3}{4}$  NAT. SIZE. FROM A PHOTOGRAPH.

*narrow preacetabular notches. Sacrals ankylosed, with rounded ventral surfaces. Anterior end of pubis broad.*

*Detailed description.*—The ilium, of which a representation is given in figs. 45 and 46, is characterized by its narrow, vertical depth. The acetabular notch is very shallow and short, while the preacetabular notch is narrow, due to the lower point of origin of the preacetabular process and the more elevated direction of the pubic process, which, in all other species is deflected more ventrally (see Plate 14). Com-

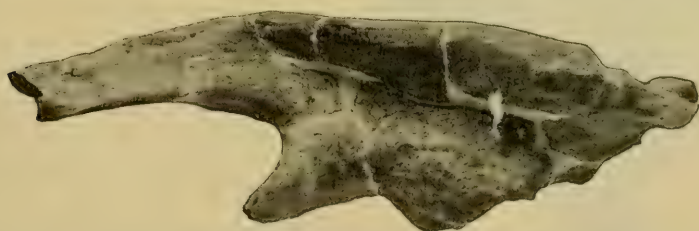


FIG. 46.—LEFT ILIUM OF CAMPTOSAURUS DEPRESSUS. CAT. No. 4753, U.S.N.M. HOLOTYPE.  $\frac{3}{4}$  NAT. SIZE. PREACETABULAR PROCESS WANTING, AND THE UPPER POSTERIOR PORTION IS CRUSHED DOWN SOMEWHAT FROM ITS NORMAL OUTLINE. FROM A PHOTOGRAPH.

pared with the ilium of *C. browni*, its nearest ally, *C. depressus* appears to indicate a smaller form. The interval between the pre- and post-acetabular notches is comparatively short, measuring 141 mm., while in *C. browni* it is 204 mm. The vertical height of the left ilium from the inferior border of the middle of the acetabulum, allowing for slight crushing, is about 105 mm. As shown by the anterior portion of the right ilium (see fig. 45), the long, curved

<sup>a</sup> Proc. U. S. Nat. Mus., XXIII, 1901, p. 591, pls. xxiii, xxiv.

<sup>b</sup> Science, XVI, Sept. 12, 1902, p. 435.



preacetabular process is terminated by a somewhat more angularly pointed end than the rounded, more spatulate type found in *C. dispar* (see fig. 29). With the exception that the ischiac process is not so robust, in nearly all other respects the ilia appear very similar to those of the better known species. The contour of the

posterior end, due to the damaged condition of both elements, can not be determined at this time.

Turning now to the sacral and caudal vertebræ associated with the ilia, it may be observed that the sacrals are characterized by the ankylosis of all their centra and their quite evenly rounded hæmal surfaces, there being just the faintest indication of the presence of a median keel upon Sacrals I, II, and III. None shows the flattened ventral surfaces observed in the paratype of *C. dispar*, No. 1877a, Yale Museum. In this respect, except in size, they more nearly resemble the sacrals of *C. nanus*.

From the fragmentary evidence, it appears there were at least seven vertebræ ankylosed by their centra in this region, the most anterior of which is a sacro-dorsal, the posterior one likely representing



FIG. 47.—ANTERIOR PORTION OF RIGHT ILIUM OF CAMPTOSAURUS DEPRESSUS. CAT. NO. 5820, U.S.N.M.  $\frac{1}{2}$  NAT. SIZE. FROM A PHOTOGRAPH.

a sacro-caudal, as in *C. browni*. Attached to the rock, which also holds the left ilium, are a number of spinous processes, which, if they pertain to the sacrum, show the spines as being much narrower antero-posteriorly, and without the heavy expanded tops of *C. dispar*.

The caudal centra show no distinctive characters, but, as in the other species, the anterior caudals show the same obliquity of the centrum, the small neural canal, the wide transverse processes, and the slightly biconcave cupping of the articular ends. The diameter

of the anterior caudal centra is greater vertically than transversely. One of the sacro-caudals shows it to have had a transverse process whose greatest width, at the point of origin at least, is in the vertical direction. The more distal caudal vertebræ, of which there are three present, show the same cylindrical shape, with long pre- and post-zygapophyses, as found in *C. browni*.

The principal dimensions of the holotype are as follows:

	mm.
Vertical depth of ilium from middle of acetabular border (estimated)----	105
Distance between pre- and post-acetabular notches-----	141
Width of pubis 63 mm. from the anterior end-----	105
Greatest length of sacro-dorsal-----	58
Greatest length of first sacral-----	53
Greatest length of second sacral-----	56
Greatest vertical depth of sacro-dorsal (anterior end)-----	70
Greatest length of caudal centrum bearing chevron (second?)-----	51
Greatest width anterior end of caudal centrum bearing chevron (second?)--	66
Greatest height anterior end caudal centrum bearing chevron (second?)--	76

A second specimen, Cat. No. 5820, U.S.N.M., consisting of the well preserved anterior portion of a right ilium, collected by Mr. J. L. Kenney from the Morrison beds of the Jurassic, near Como, Albany County, Wyoming, undoubtedly pertains to this species (see fig. 47).

#### CAMPTOSAURUS BROWNII, new species.

*Holotype*.—Cat. No. 4282, U.S.N.M. From the Jurassic (Morrison beds), Quarry No. 13, 8 miles east of Como, Albany County, Wyoming. Collected by Mr. Fred Brown during the years 1885 and 1886. Named for the collector, whose discoveries of important fossil specimens have done much to further the science of paleontology.

The typical specimen consists of a considerable portion of the skeleton, and since the elements have been listed on page 203, it appears unnecessary to again enumerate them. As this skeleton is the basis for that part of the present paper devoted to the osteology of *Camptosaurus*, where a detailed description of the bones composing it will be found, it is necessary here to discuss only those characteristics by which it differs from the other known species.

*Specific characters*.—*Ilium* of moderate depth, with long pre- and post-acetabular processes; the hinder part especially narrow; superior border slightly convex with oblique posterior portion short. Seven vertebræ, of which five are considered sacral, united by suture in sacral region. Peg-and-notch articulation confined to the posterior members and extending into the anterior caudals. Anterior sacral vertebræ compressed transversely. Last dorsal with ventral keel. *Ischia* slender with light expanded distal ends.

Typically the skeleton represents an animal about 16 feet in length, intermediate in size between *C. dispar* and *C. medius*. While it ap-

proaches the former more nearly in size, it resembles the latter in the comparative lightness of its skeletal structure.

The cervical vertebrae of *C. browni*, when compared with those of *C. dispar*, show a much narrower ventral keel and deeper lateral depressions. The dorsal region, on account of the lack of material, I am unable to contrast with the other species, excepting *C. nanus*, the dorsals of which may be readily distinguished on account of their small size and the thinness of the spinous processes, which are without decided thickening of their superior terminations.

The last, or sacro-dorsal, has a short but decided ventral keel which at once distinguishes this element from the smoothly rounded hamal surface of this vertebrae in *C. dispar*, or the faint keeled ones as found in *C. depressus*, *C. nanus*, and *C. prestwichii*.

The sacral region of *C. browni* resembles *C. depressus* most nearly in having seven vertebrae united by suture, of which five are considered true sacrals in the former species. The sacrum differs from *C. dispar* in the increased number of sacral vertebrae, the absence, in the anterior elements, of the peg-and-notch articulation, and its continuance into the caudal region, and by the more compressed and keeled anterior centra. The absence of the peg-and-notch articulation in the sacrals of *C. nanus* and *C. prestwichii* at once separates them from *C. browni*.

Outside of the anterior caudals, as noted above, the other vertebrae of the tail show no distinctive features.

As known at the present time, the ilium is one of the most characteristic bones of the entire skeleton of *Camptosaurus*, and since this element is present in all of the holotypes of the American species, excepting *C. amplus*, it offers a basis of comparison equal in importance to the differences displayed in the several species. The length of the ilium (see fig. 30), which wants the extremity of the preacetabular process, is quite equal to that of the average adult individual of *C. dispar* (see figs. 1 and 3, Plate 14), although its greatest depth is considerably less. The preacetabular process when complete was long, the superior border slightly convex, and the post-acetabular portion long and especially narrow, the angular oblique border of the supero-posterior end being short. Compared with the ilia of the other species, the difference in the form of the hinder half, coupled with its other proportions, would, apart from other evidence, indicate the specific distinctness of its owner. In contour the ilium is intermediate between *C. medius* on the one hand and *C. depressus* on the other, as may be seen by comparing figures. Compared with *C. depressus*, it shows a much wider preacetabular notch, a deeper acetabulum, and a greater depth of the bone as a whole.

The pathological condition of the right ilium of *C. browni* is of interest in showing to what extent the shape of a bone may be modi-



fied by external injury. On the posterior half, the comparatively thin, plate-like part of the ilium is divided vertically, the two halves swelling out to form the walls of a cavity which extends downward, emerging on the ventral border. The cavity is longer than wide, measuring on the upper border of the opening 86 mm. in a longitudinal direction and 46 mm. in the transverse, the ventral exit being considerably smaller. As indicated by a deep depression on the dorsal border, the injury was probably received from above.

The exostosis of the bone was greatest on the front side of the cavity where it measures 72 mm. in width. The normal diameter of this part of the ilium, as shown by one of the opposite side, is only 21 mm. A second injury was found on one of the caudal vertebrae near the root of the tail, as indicated by the pathologic condition of the spinous process, which is considerably enlarged and has near its base an elongated opening which perforates the bone. While the wound in the ilium must have been an exceedingly painful one at the time of infliction, it in no way utterly disabled the animal, at least to the extent of leading to its death, for, as shown by the specimens, all of the broken margins of the bone had healed. Although these injuries may have been inflicted by some of its large carnivorous contemporaries, the position of the wounds suggests the idea that this individual was a female who might have received the injuries during copulation.

The ischia of *C. browni* are comparatively slender, and while there is a considerable expansion of their distal extremities, they lack the massiveness of those of *C. dispar*. In the lightness of the structure of these elements, they approach *C. medius* most nearly.

The fore limbs and feet show no distinguishing characteristics. The principal measurements of the vertebrae and other parts will be found in that part of the paper devoted to the osteology of *Camptosaurus*.

#### GEOGRAPHICAL AND GEOLOGICAL DISTRIBUTION.

In North America, camptosaurian remains have been found in southeastern Wyoming, in Albany and Carbon counties;<sup>a</sup> Colorado, near Canon City, and in the "Garden of the Gods", near Colorado Springs; South Dakota, in Custer County, in the vicinity of Buffalo Gap. Beyond the limits of the United States, specimens which have been referred to *Campptosaurus* have been found in England, Isle of Wight, and Hungary.

All of the American species, with the possible exception of *C. depressus*, are from the Morrison beds (Atlantosaurus beds of Marsh),

<sup>a</sup> In the Journal of Geology, XIII, No. 4, 1905, p. 348, Dr. S. W. Williston reports the occurrence of *Laosaurus* remains in Fremont County, near Lander, Wyoming, in deposits considered lower Cretaceous in age.

of the Jurassic, but Marsh's statement that "they occur in successive deposits of the same general horizon, the smallest species below, the largest above,"<sup>a</sup> can not be verified, and is not borne out by the structural characteristics of the typical specimens. Moreover, as shown by the original field labels still remaining with the type material, *C. dispar*, *C. medius*, and *C. nanus* came from the same quarry (No. 13) and in all probability were found at the same level. Although the holotype of *C. amplus* was found in the same general area, it is from another quarry in a region where it is difficult to trace stratigraphic horizons. It also appears from Marsh's own writings that he was not quite clear as to their stratigraphic positions, for in 1879<sup>b</sup> at the close of his description of *C. amplus*, he says: "The remains of the present species are from a lower horizon in the Jurassic than those described above [*C. dispar*], but within the limits of the *Atlantosaurus* beds." He thus places the larger species at a lower level, which is contradictory to his later statements.

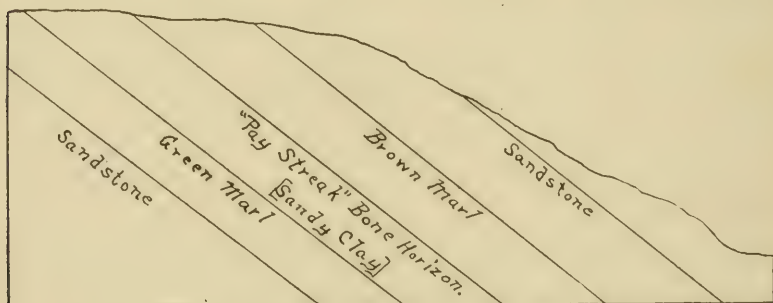


FIG. 48.—SECTION OF QUARRY 13. MADE BY MR. FRED BROWN IN 1884.

Since Quarry No. 13 has furnished four of the holotypes pertaining to the genus *Camptosaurus*, besides a vast quantity of other material, the exact stratigraphic position of the bone-bearing layer is of considerable interest. A clue to the position of this layer was found in a rough section of the strata exposed in working this quarry, made by Mr. Fred Brown in 1884 (see fig. 48).

The fossils occur here in a layer of sandy clay,<sup>c</sup> as I have determined from the matrix still adhering to bones, and, as seen in Brown's section, the bone-bearing layer ("pay streak") is intercalated between layers of marl or clay, green below and brownish above, all three layers lying between bands of sandstone.

<sup>a</sup> Amer. Journ. Sci., XLVIII, 1894, p. 85.

<sup>b</sup> Idem, XVIII, 1879, p. 503.

<sup>c</sup> On page 199 of the present paper, Mr. W. H. Reed is quoted as also noting the sandy nature of the matrix in which the fossils occur as being unusual.

In comparing the conditions here with the sections so carefully worked out by Dr. F. B. Loomis<sup>a</sup> at Como Bluff and Little Medicine, in an area a few miles to the west of that under discussion, it appears that this sandy layer may be tentatively correlated with No. 28 of his section (see Plate 20), which he describes as follows:

No. 28 is a gray sandstone in which the rich Bone Cabin Quarry is situated, and also the Stegosaurus Quarry. The sandstone varies extremely in hardness, being, in the south part of Bone Cabin Quarry, soft and mixed with considerable clay so that it is workable with an awl. In the northern part of the quarry, however, there are bands of the firmest sort of sandstone. In Como Bluff the layer is clay with merely an admixture of sand. Bone Cabin Quarry has yielded a great variety of genera: *Diplodocus*, *Morosaurus*, *Brontosaurus*, *Allosaurus*, *Ceratops*, *Camptosaurus*, *Stegosaurus*, as well as several genera of carnivorous Dinosaurs; also *Compsemys* and *Goniopholis*.

The correctness of the above correlation appears to be indicated (1) by the similar nature, lithologically, of the materials composing the bone horizon, (2) a similarity in the over and underlying strata, (3) the likeness of the faunas from the two localities. If later investigations show this provisional correlation to be correct, it is of the utmost importance as definitely locating the horizon from which the holotypes of the following species have come: *Camptosaurus dispar*, *C. medius*, *C. nanus*, *C. browni*, *Dryosaurus altus*, and *Diracodon laticeps*. Among the other dinosaurian genera recognized from quarry No. 13 are *Stegosaurus*, *Allosaurus*, *Coelurus*, and *Morosaurus*, as well as the turtle, *Glyptops* and the crocodile *Goniopholis*, and fish remains, which, however, are too fragmentary to admit of identification. By comparing the faunal lists of the two quarries, it will be observed that they are quite alike, although Bone Cabin Quarry predominates in representatives of the Opisthocoelia (Sauropoda), Quarry 13 in members of the Orthopoda (Predentata). This observation would also apply to the relative numbers of individuals of each group found in the two quarries. Quarry No. 13, as shown by the maps, was especially rich in stegosaurian and camptosaurian remains.

With the permission of Dr. F. B. Loomis, I reproduce (Plate 20, figs. 1 and 2) sections of the Little Medicine and Como Bluff exposures, which, according to his measurements, show the 5-foot sandy layer No. 28 to be within 60 feet of the overlying Cretaceous (Dakota). This is the highest known horizon of the Jurassic in which camptosaurian bones have been found, and the discovery at this level in the famous "Bone Cabin Quarry" of a skeleton of *C. nanus* (see Plate 19), strengthens somewhat the assumption of the contemporaneity of this layer with the bone horizon of Quarry 13.

<sup>a</sup> Bull. Amer. Mus. Nat. Hist., XIV, 1901, pp. 189-197, pl. XXVII, figs. 2, 3.



The finding of *Camptosaurus* remains in the Lakota, near Buffalo Gap, South Dakota, appears to extend the geological horizon of this genus. The occurrence of these fossils is described by Mr. N. H. Darton<sup>a</sup> as follows:

The formation has yielded a large number of cycads, notably those described by Mr. Lester F. Ward. These and associated plants are regarded by Mr. Ward as Cretaceous in age. In 1898 I discovered saurian bones in or near the cycad horizon at Buffalo Gap, but as they are of new species it is difficult to obtain from them any evidence bearing on the age of the formation. If it were not for the evidence of the flora, these bones would be regarded as late Jurassic in age. \* \* \* The bone bearing beds are in the middle of the Lakota formation, or about 90 feet above the unconformity on the Unkpapa sandstone which is approximately the horizon that has yielded the cycads between Edgemont and Minnekata, near Blackhawk and elsewhere about the hills.

The vertebrate fauna of the above horizon, as now known, consists of *Hoplitosaurus* (*Stegosaurus*) *marshi* (Lucas) and *Camptosaurus depressus*, new species, while the presence of a sauropodous dinosaur is indicated by some fragmentary bones found associated with the type material.

That the bone-bearing layer at Buffalo Gap is later than the fossil horizon in Quarry 13, Como, Wyoming, appears quite probable, although the evidence as yet is insufficient to conclusively establish the fact. *Hoplitosaurus* has its nearest ally in *Polocanthus* of the Wealden. While the former genus is known by a single fragmentary specimen only, it may, from its geological position, represent a form intermediate between *Stegosaurus* of the Jurassic, and *Nodosaurus*, *Stegopelta*, and *Anchylosaurus* of the American Upper Cretaceous.

Although the typical specimen of *C. depressus* is fragmentary, such parts as are preserved appear to show that of all the known forms of *Camptosaurus* this species approaches the Wealden *Iguanodon* most closely, as indicated by the narrowness of the ilium and the coossification of the sacral vertebrae.

As has been pointed out in the preceding pages, the *Camptosaurus* remains from Quarry 13, when compared with *Iguanodon*, show a more generalized structure, which suggests a somewhat greater antiquity for the beds in which they are found. In this connection it is a significant fact that of the several European species referred to *Camptosaurus*, the only valid one is *C. prestwichii* from the Kimmeridge Clay, and its affinities appear to be nearest to *C. nanus*, the holotype of which was found in Quarry 13. Corroborative evidence is furnished by the abundant remains of *Stegosaurus* found in the above quarry (see Plate 6), which genus is so closely allied to *Dacn-*

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<sup>a</sup>21st Ann. Rept. U. S. Geol. Surv., Pt. 4, 1899-1900, p. 527.

*trupus*<sup>a</sup> (*Omosaurus*) from the Kimmeridge that Marsh believed them to be identical.

It is unfortunate that the early paleontologists rarely gave any precise location, much less the exact geological horizon from which typical specimens were obtained, so that the faunas of the upper and lower parts of the American Jurassic, except in a few instances, have never been differentiated. The whole fauna has been included under the term Upper Jurassic, and only in the last few years have a few authorities separated some of the upper part as lower Cretaceous. The vertebrates found in the Lakota at Buffalo Gap point to its being the equivalent of the Wealden of England. Assuming, as many authorities do, that the Wealden is really Jurassic, these beds would then represent the uppermost part of that formation.

The above evidence, then, is in favor of the contemporaneity of the Buffalo Gap horizon with the Wealden, and indicates that the age of the Quarry 13 bone layer is greater than the Wealden. Such evidence as is shown by the Camptosauridæ not only supports Hatcher's contention<sup>b</sup> that the lower members of the Morrison (Atlantosaurus Beds) are below the Wealden, but that they are of greater age than the Purbeck and possibly equivalent to the Kimmeridgian.

#### RESTORATION OF CAMPTOSAURUS.

Marsh gave us the first skeletal restoration of *Camptosaurus*, here reproduced as Plate 18. While this reconstruction gives a good idea of the animal as a whole, it is now known, as has been pointed out earlier in the present article, to be in error in several particulars. The most striking change brought about by this more recent study is the shortening of the presacral region, which was made too long by Marsh, owing to an overestimate of the number of presacral vertebræ. In his figure (see Plate 18) there are 30 presacral vertebræ, 9 of which are considered as belonging to the cervical region, thus leaving 21 thoracic vertebræ. Two specimens in the U. S. National Museum agree in having 16 dorsals each. If, then, this latter number is correct, the presacral series would be shortened by 5 vertebræ, making the proportions of the animal markedly different from the first conception of its appearance (compare with Plate 19). Even though it ultimately be found that *Camptosaurus* has 18 dorsal vertebræ (a possibility indicated by the occurrence of that number in the holotype of *C. prestwichii* and in the allied *Iguanodon*), it would still mean the shortening of the column by 3 vertebræ, which would have lessened the distance between the fore and hind limbs, producing a more compactly built animal than appeared in the first reconstruction.

<sup>a</sup> Science (N. S.), XVI, 1902, p. 435.

<sup>b</sup> Memoirs, Carnegie Museum, III, 1903, p. 68.

Although there is a considerable disparity in length between the fore and hind limbs, there appears to be some evidence to show that the bipedal mode of progression was not habitual. While I do not wish to be understood as believing that the upright position was not frequently assumed, still it appears to me that the quadrupedal posture was used more frequently than has been generally supposed. This is shown by the compact, ossified carpus, with smooth, well-defined articulating surfaces, which is supported by comparatively short and stout metacarpals, whose function was that of support rather than prehension. When compared with those of animals whose mode of progression is normally bipedal, the suggestion advanced here becomes more apparent. *Trachodon* has slender, elongated metacarpals and imperfectly ossified carpus, and *Iguanodon* also has a tendency toward the lengthening of the metacarpals, though not so marked as in the former genus. The curved femur is also indicative of a flexed limb, which would have equalized somewhat the difference in length between the fore and hind legs. This character of the femur is in striking contrast to the straight femur of both *Iguanodon* and *Trachodon*, a provision, as in the Proboscidae, for the support of great weight. The obliquity of the anterior caudal centra indicates a rapid dropping of the tail as it leaves the sacrum, which is also suggestive of a normal quadrupedal position. In the two genera mentioned above the caudals extend straight out from the sacrum without appreciable ventral deflection.

Through the courtesy of Dr. W. D. Matthew, of the American Museum of Natural History, I am enabled to present in Plate 19 the first skeleton of *Camptosaurus* to be mounted, which gives a truer conception of the animal than is obtained from the earlier reconstructions. As seen in the figure, the head is comparatively small, being carried on a gracefully curved neck of moderate length. The thoracic region, which has been given 16 dorsals, is of moderate length, borne on stout, clawed limbs, of which the hinder are longer and stouter than the fore. In life this animal was evidently strong and agile in movement. The tail was long, nearly equaling half the total length of the skeleton, and in life it probably served as a balancing organ when the upright bipedal posture was assumed.

Unlike many of the other predentate dinosaurs, there have been no dermal scutes nor ossicles found, so we have no knowledge as to the dermal covering.





#### EXPLANATION OF PLATE 6.

Diagrams 5, 7, and part of 4, of Quarry 13, near Como, Albany County, Wyoming, worked by Mr. Fred Brown for Prof. O. C. Marsh, during the years 1884, 1885, and 1886. The numbered bones show the positions in which the various elements of the holotype of *Camptosaurus browni*, Cat. No. 4282, U.S.N.M., were found in the quarry. The unnumbered bones scattered about pertain chiefly to members of the Stegosauria.

A, Plesiotype of *Diracodon laticeps*, Cat. No. 4288, U.S.N.M.

B, Series of caudals and dermal plates of *Stegosaurus*, Cat. No. 4714, U.S.N.M.  
The scale is about 4 feet to the inch.











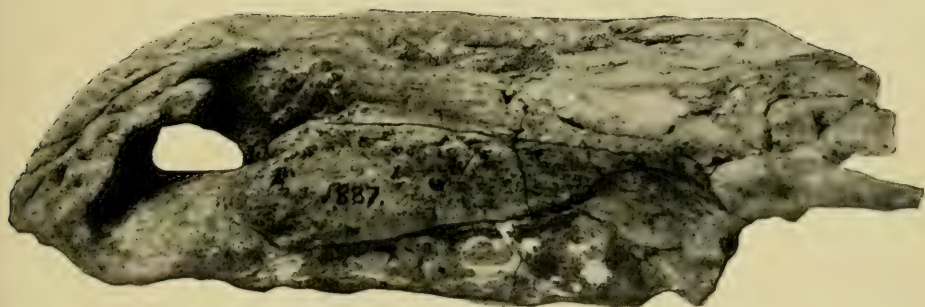




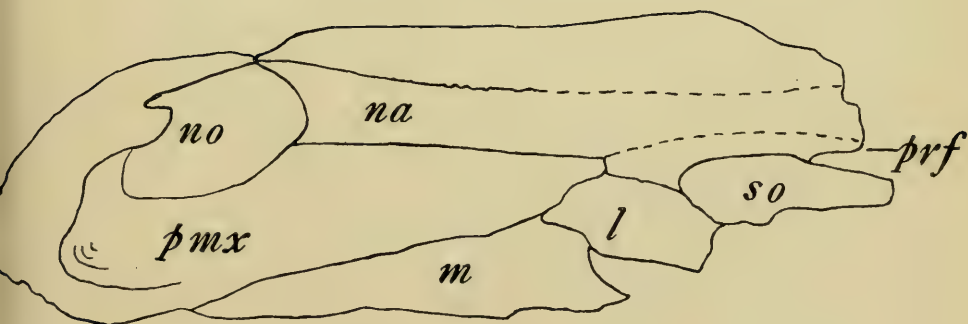
EXPLANATION OF PLATE 7.

- FIG. 1. Anterior part of skull, *Camptosaurus amplius?* Marsh. No. 1887, Yale Museum. About  $\frac{2}{3}$  nat. size.
2. Explanatory figure of same: *l*, lachrymal; *m*, maxillary; *na*, nasal; *no*, narial orifice; *pmx*, premaxillary; *prf*, prefrontal; *so*, supraorbital.

1



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ANTERIOR PORTION OF SKULL OF CAMPTOSAURUS AMPLUS?



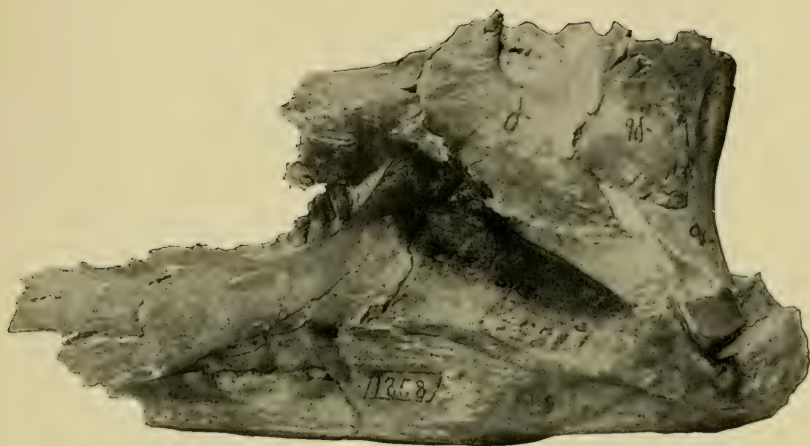




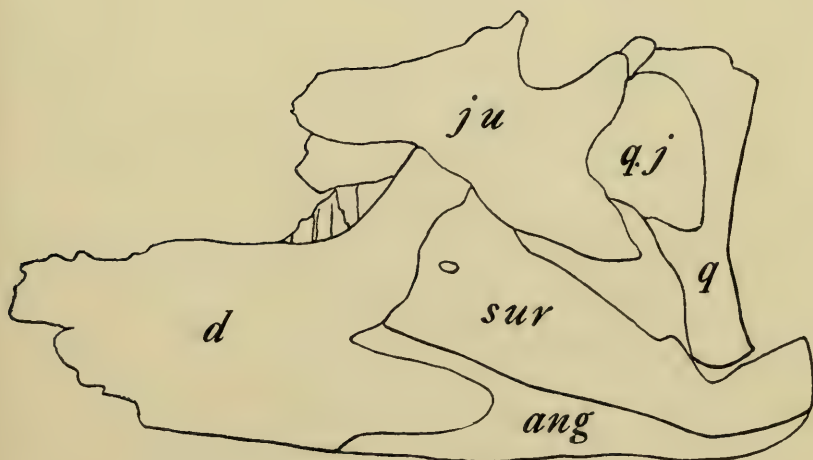
#### EXPLANATION OF PLATE 8.

- FIG. 1. Posterior part of skull, *Camptosaurus amplus?* Marsh. No. 1887, Yale Museum.  $\frac{2}{3}$  nat. size. External view.
2. Explanatory figure of same: *ang*, angular; *d*, dentary; *ju*, jugal; *q*, quadrate; *qj*, quadratojugal; *sur*, surangular.

1



2



POSTERIOR PART OF SKULL OF CAMPTOSAURUS AMPLUS?







#### EXPLANATION OF PLATE 9.

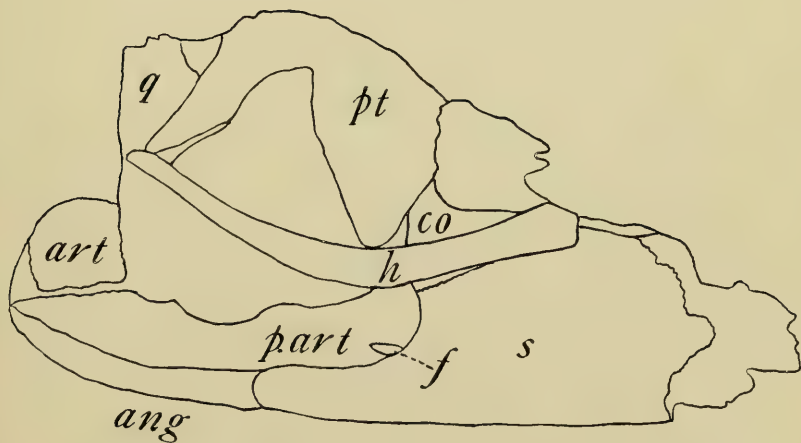
FIG. 1. Posterior part of skull, *Camptosaurus amplus?* Marsh. No. 1887, Yale Museum.  $\frac{2}{3}$  nat. size. Internal view.

2. Explanatory figure of same: *ang*, angular; *art*, articular; *co*, coronoid; *f*, internal mandibular foramen?; *h*, hyoid; *p*, *art*, prearticular; *pt*, pterygoid; *q*, quadrate; *s*, splenial.

1



2



POSTERIOR PART OF SKULL OF CAMPTOSAURUS AMPLUS?







EXPLANATION OF PLATE 10.

- FIG. 1. Posterior portion of skull, *Camptosaurus dispar* Marsh. Cat. No. 5473, U.S.N.M.  $\frac{1}{2}$  nat. size. Seen from above. From a photograph.
2. Explanatory figure of same. *al. sp.*, alisphenoid; *c*, occipital condyle; *f*, frontals; *p*, parietal; *pf*, postfrontal; *poc*, paraoccipital process or opisthotic; *so*, supraoccipital.

1



2



POSTERIOR PART OF SKULL OF CAMPTOSAURUS DISPAR.







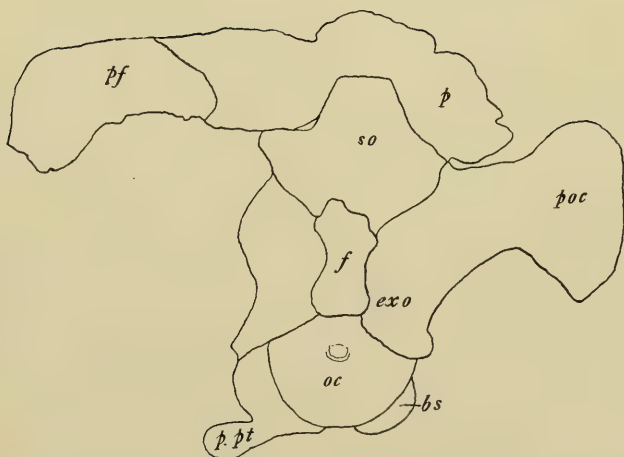
#### EXPLANATION OF PLATE 11.

- FIG. 1. Occipital region of skull, *Camptosaurus dispar* Marsh. Cat. No. 5473, U.S.N.M.  $\frac{1}{2}$  nat. size. Posterior view. From a photograph.
2. Explanatory figure of same. *bs*, basisphenoid; *exo*, exoccipital; *f*, foramen magnum; *oc*, occipital condyle; *p*, parietal; *pf*, postfrontal; *poc*, paraoccipital process or opisthotic; *p. pt.*, process which meets pterygoid; *so*, supraoccipital.

1



2



OCCIPITAL REGION OF SKULL OF CAMPTOSAURUS DISPAR.







EXPLANATION OF PLATE 12.

Complete neck and posterior portion of skull *Camptosaurus dispar* Marsh.  
Cat. No. 5473, U.S.N.M.  $\frac{1}{3}$  nat. size. Viewed from the left side. From a photograph.



NECK AND PART OF SKULL OF CAMPTOSAURUS DISPAR.







EXPLANATION OF PLATE 13.

Sacrum of *Camptosaurus dispar* Marsh. No. 1877a, Yale Museum. About  $\frac{1}{3}$  nat. size. Paratype: viewed from the left side. *a*, sacro-dorsal; 1, 2, 3, and 4, sacra one to four, respectively. From a photograph.



SACRUM OF CAMPTOSAURUS DISPAR.



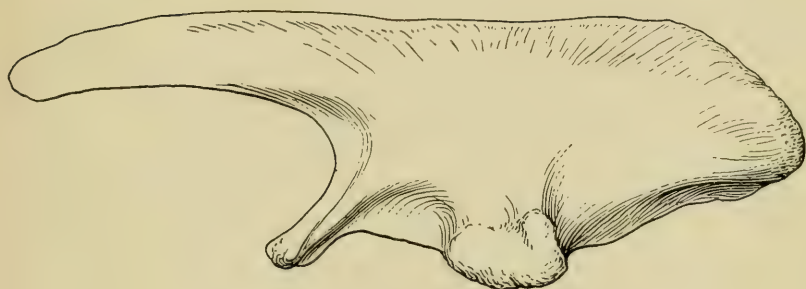




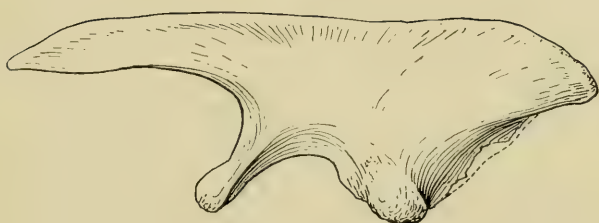
EXPLANATION OF PLATE 14.

- Fig. 1. Left ilium *Camptosaurus dispar* Marsh. Cat. No. 5473, U.S.N.M.  $\frac{1}{8}$  nat. size. Pubic peduncle restored after Cat. No. 5818, U.S.N.M.
2. Left ilium *Camptosaurus nanus* Marsh. Cat. No. 2210, U.S.N.M. Holotype.  $\frac{1}{3}$  nat size.
3. Left ilium *Camptosaurus browni*. Cat. No. 4282, U.S.N.M. Holotype.  $\frac{1}{6}$  nat. size.

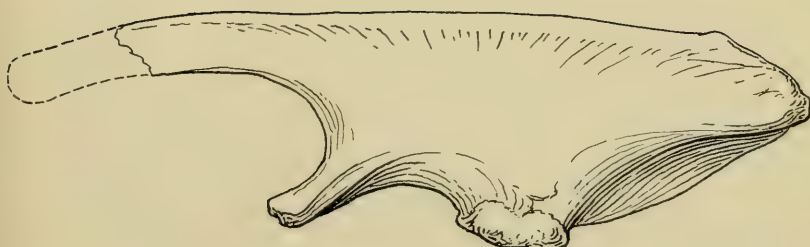
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2



3



ILIA OF THREE SPECIES OF CAMPTOSAURUS.

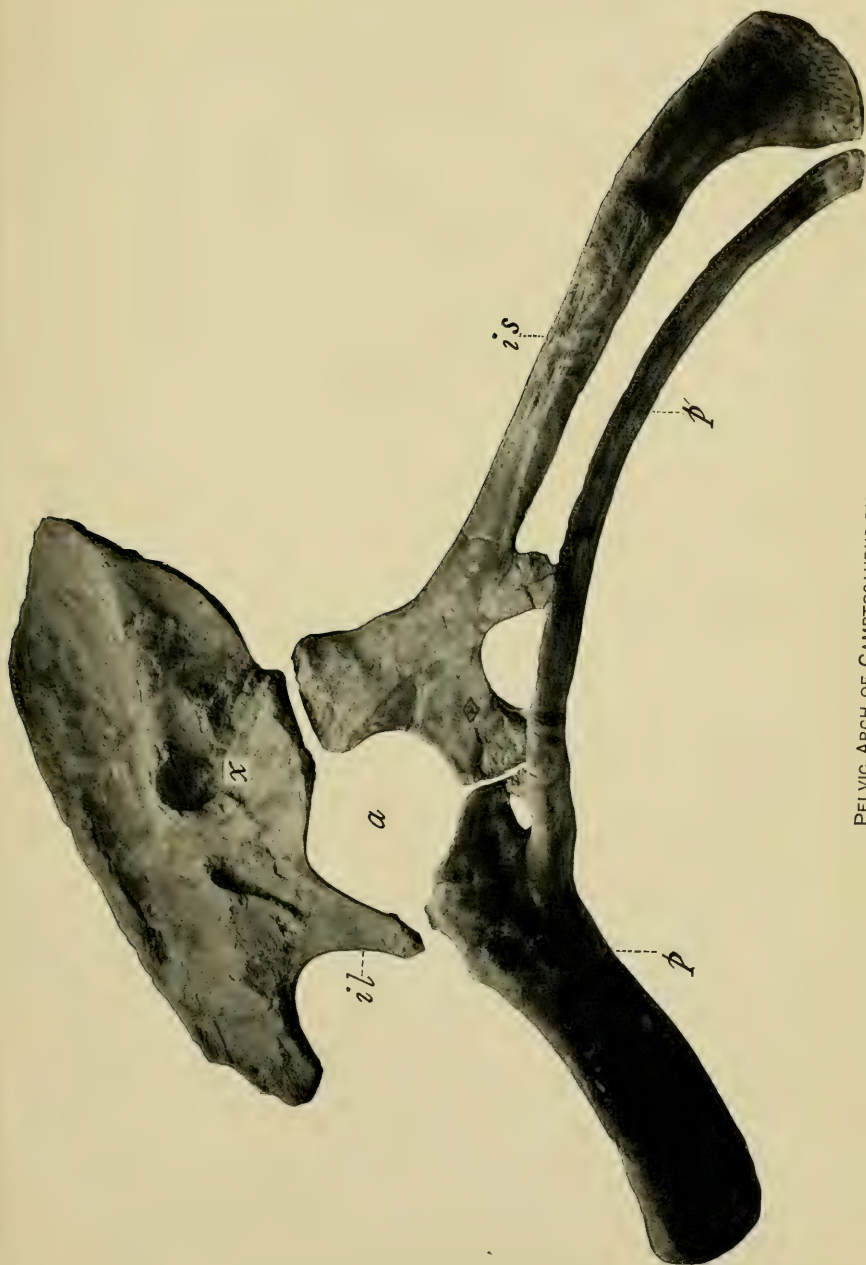






#### EXPLANATION OF PLATE 15.

Pelvic arch *Camptosaurus dispar* Marsh. No. 1878, Yale Museum. Paratype. One-fifth nat. size. Internal view of right side: *a*, acetabulum; *il*, ilium; *is*, ischium; *p*, pubis; *p'*, postpubis; *x*, depressions for articulation of sacral ribs. From a photograph.



PELVIC ARCH OF CAMPTOSAURUS DISPAR.

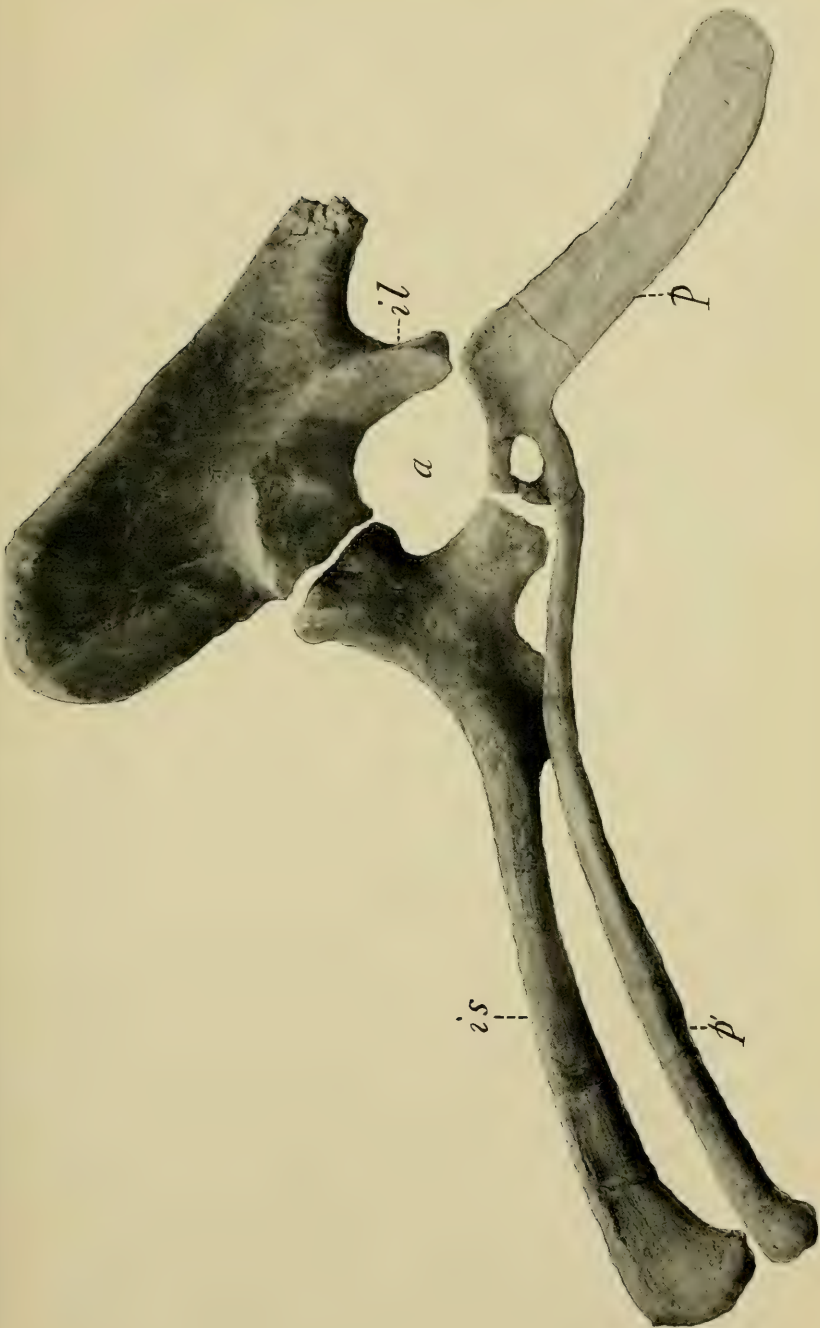






EXPLANATION OF PLATE 16.

Pelvic arch *Camptosaurus medius* Marsh. No. 1880, Yale Museum. Holotype. About one-fourth nat. size. Viewed from the right side: *a*, acetabulum; *il*, ilium; *is*, ischium; *p*, pubis; *p'*, postpubis. From a photograph.



PELVIC ARCH OF CAMPTOSAURUS MEDIUS.

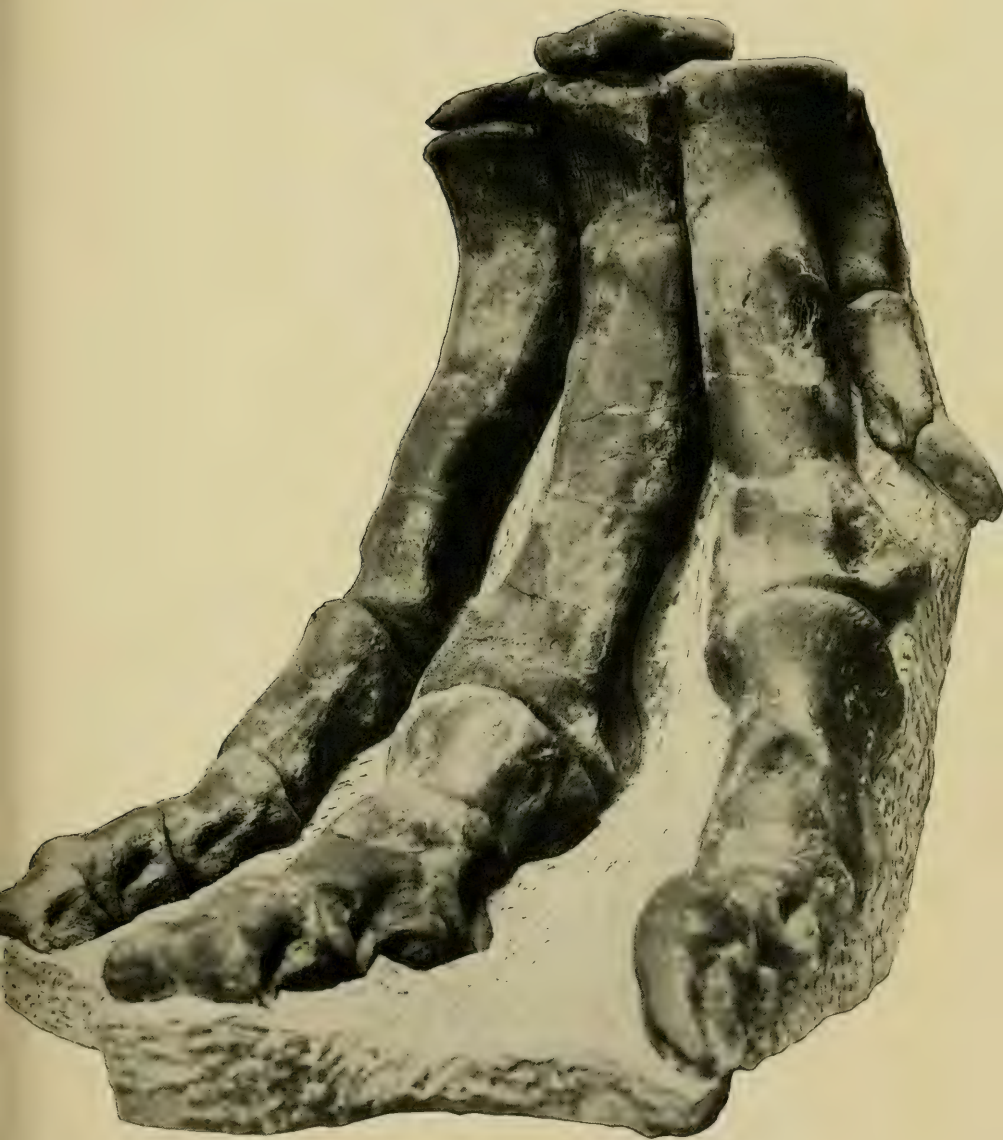






EXPLANATION OF PLATE 17.

Right hind foot *Camptosaurus amplus* Marsh. No. 1879, Yale Museum. Holotype. Viewed diagonally from the front. Less than one-third nat. size. From a photograph.



RIGHT HIND FOOT OF CAMPTOSAURUS AMPLUS.

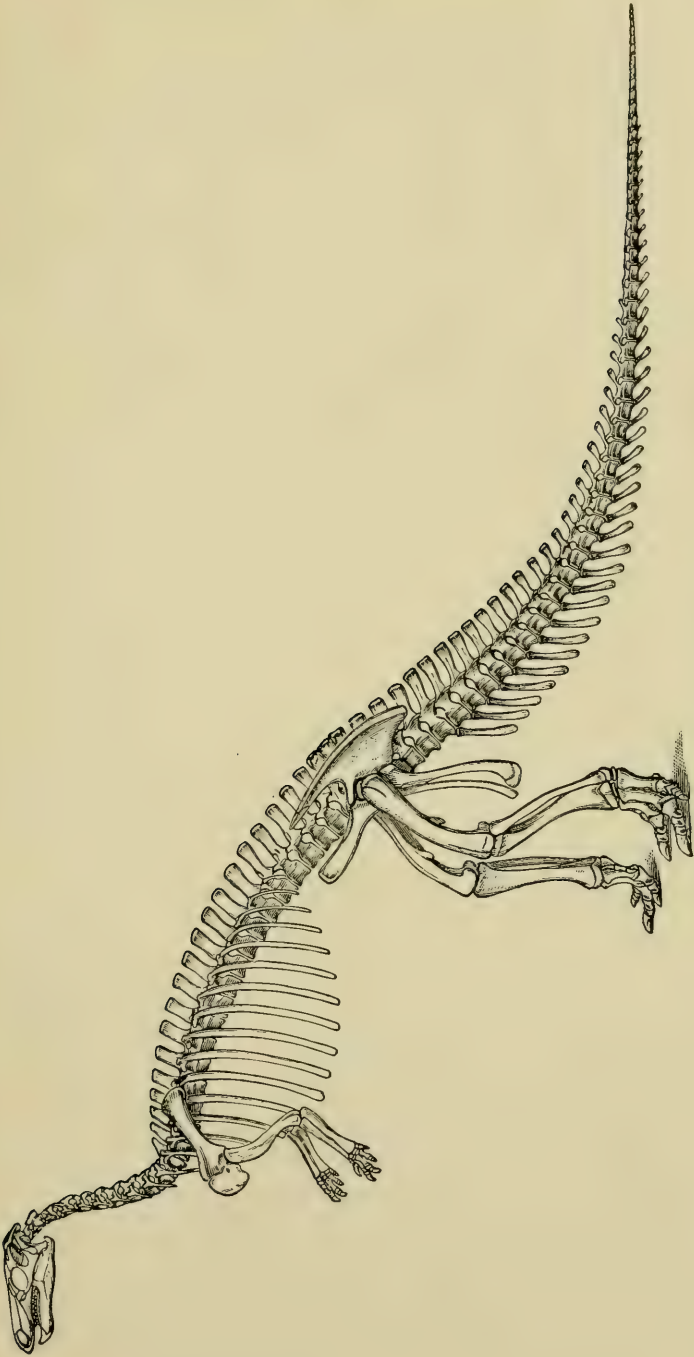






EXPLANATION OF PLATE 18.

Restoration of *Camptosaurus dispar* Marsh. Based upon specimens in the Yale Museum. One-thirtieth nat. size. After Marsh.



RESTORATION OF CAMPTOSAURUS DISPAR.

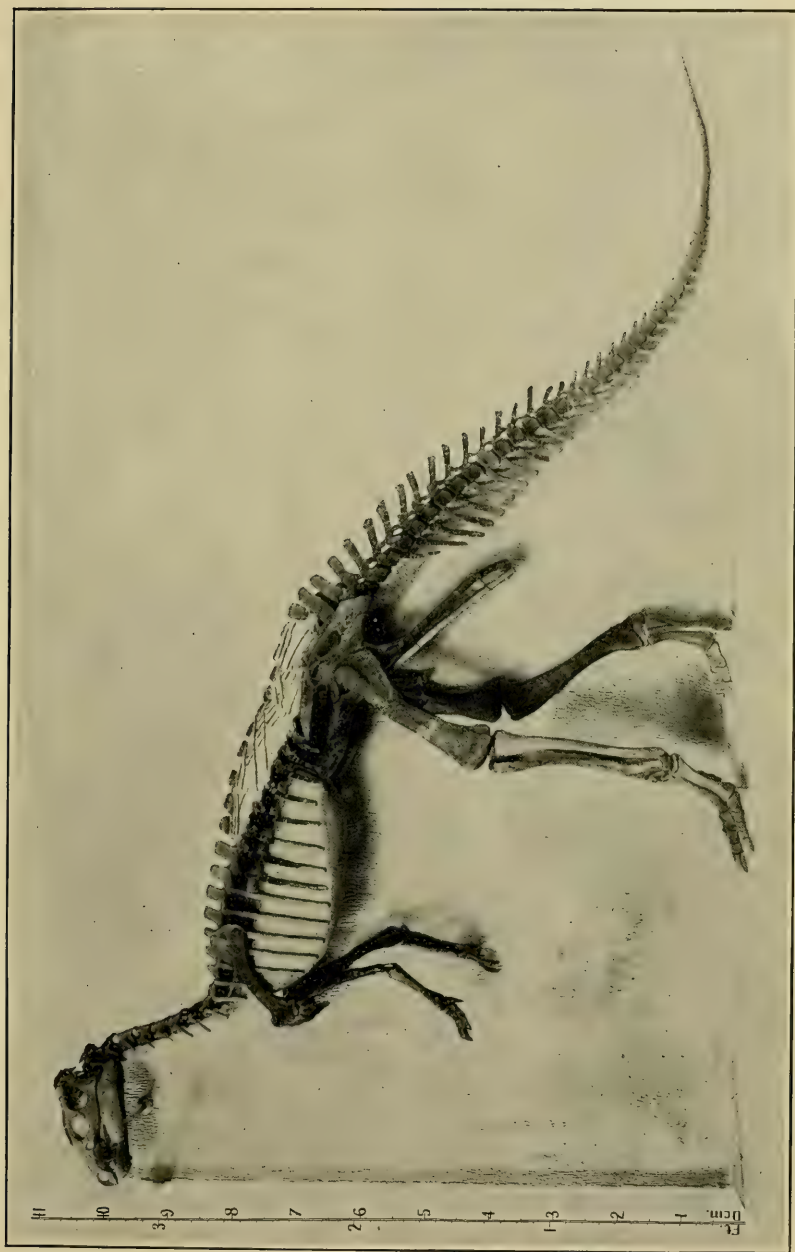






EXPLANATION OF PLATE 19.

Mounted skeleton of *Camptosaurus nanus* Marsh. No. 6120 American Museum of Natural History. About  $1\frac{1}{2}$  nat. size. Through the courtesy of Dr. W. D. Matthew.



MOUNTED SKELETON OF CAMPTOSAURUS NANUS.







#### EXPLANATION OF PLATE 20.

Fig. 1. Section across Como Bluff, south side of Como anticline.

Como=Morrison (Atlantosaurus Beds of Marsh).

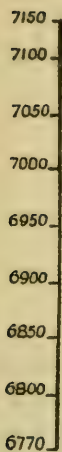
Shirley=Baptanodon Beds of Marsh.

"28. Sandy clay" is the equivalent of 28 of fig. 2.

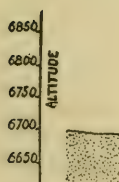
2. Section across "Bone Cabin Draw," south side of Little Medicine anticline.

"28. Gray sandstone" contains bone layer of the famous "Bone Cabin Quarry," and probably equivalent to the fossil layer of Quarry 13.

Both figures after Loomis.



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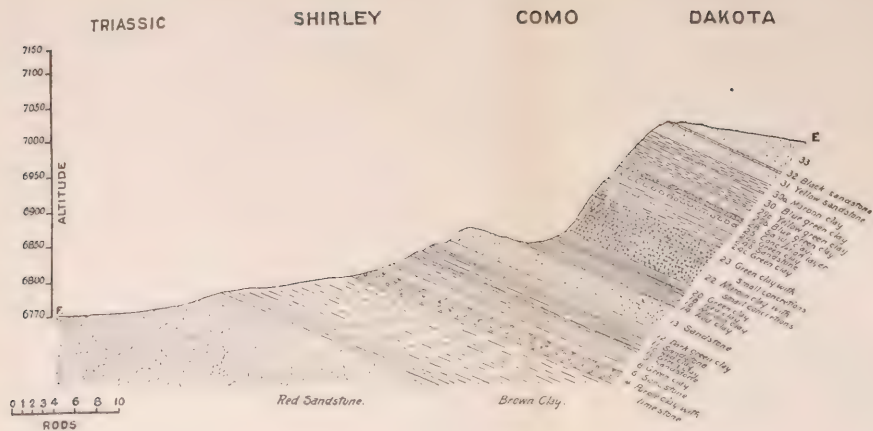


FIG. 1

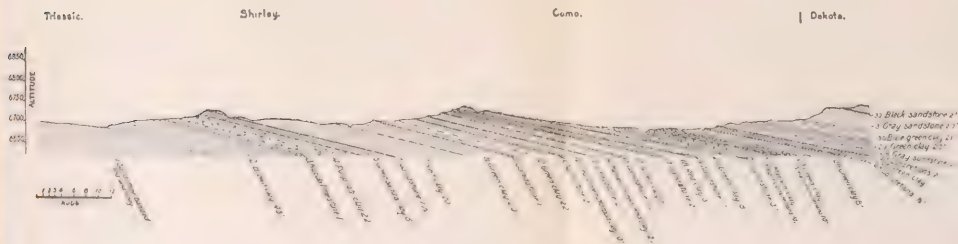


FIG. 2

SECTION OF JURASSIC EXPOSURES, NEAR MEDICINE BOW, WYOMING.



# THE COLLECTION OF ROSARIES IN THE UNITED STATES NATIONAL MUSEUM.<sup>a</sup>

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By IMMANUEL M. CASANOWICZ,  
*Of the U. S. National Museum.*

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## INTRODUCTION.

The rosary is a string of beads, generally formed into a circlet or loop, used for keeping count of prayers or formulas repeated in religious devotions. The materials of which it is made range from natural berries or common wood to costly metals and precious stones. It is best known from its use by Roman Catholics in devotion to the Virgin Mary, to which is also due the name "rosary," as will be seen further on. But long before they came into vogue in Europe and among Christians, mechanical devices for counting the repetition of prayers or mystical sentences were in use among various oriental peoples, and at present some form or other of rosary is used by about three-fourths of the world's inhabitants. Man's natural tendency to

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<sup>a</sup> Literature consulted: William Tayler, *The Rosary in India*, Journ. Soc. of Arts, XXI, No. 1068, London, May 9, 1873, pp. 461-470. Monier M. Williams, *Indian Rosaries*, The Athenæum, No. 2624, London, Feb. 9, 1878, p. 188, and, *Buddhism in its Connection with Brahmanism and Hinduism*, New York, 1889, p. 383. L. Austin Waddell, *Lamaic Rosaries, Their Kinds and Uses*, Journ. Asiatic Soc. Bengal, LXI, Pt. 1, 1892, pp. 24-33, and, *The Buddhism of Tibet, or Lamaism*, London, 1895, pp. 202-211. J. M. James, *Descriptive Notes on the Rosaries (jii dzu) as used by the Different Sects of Buddhists in Japan*, Trans. Asiatic Soc. Japan, IX, Yokohama, 1881, pp. 173-182. Ignaz Goldzieher, *Le Rosarie dans l'Islam*, Revue de l'Histoire des Religions, Jan.-Juin, 1890, XXI, pp. 295-300. Rev. Herbert Thurston, S. J., *The Archaeology of the Rosary Beads*, The Month, London, April, 1901, pp. 383-404, and *History of the Rosary in all Countries*, Scientific American Supplement, No. 1370, New York, April 5, 1902, pp. 21960-21963. John R. Volz, *Beads in the Catholic Encyclopedia*, II, New York, pp. 361-362. Much interesting information on Chinese and Japanese rosaries was also derived from manuscript notes of Miss Eliza R. Seidmore, which she deposited with the larger number of rosaries described in this paper in the National Museum. Mr. William E. Safford, of the Department of Agriculture, and Mr. Wirt Tassin, of the National Museum, kindly aided in identifying the material of the rosaries.

iteration, especially of prayers which have assumed a traditional form, to the recital of which a particular merit or potency is attributed, must have early suggested some means of assuring accuracy of the count, such as the fingers, pebbles, knotted cords, gradually evolving into the string of beads.

Following the succession in time of the appearance of the rosary in the several religious systems which are known to use it, the paper will treat first of the form and manner of its use among the Hindus or Brahmans; second, among Buddhists; third, among Mohammedans; and, fourth, among Christians.<sup>a</sup>

#### I. THE HINDU OR BRAHMAN ROSARY.

The Hindus are generally believed to have first evolved the rosary. "It is not unreasonable to conjecture," says the noted Indianist, Monier M. Williams, "that the original invention of the rosary is due to India. \* \* \* No other country in the world stands in such need of aids to religious exercises. \* \* \* The pious Hindu not only computes his daily prayers as if they were so many rupees added to his capital stock in the bank of heaven, but he sets himself to repeat the mere names of his favorite gods, and will continue doing so for hours together."<sup>b</sup> It is first mentioned in the Atharva Veda.<sup>c</sup> The Sanskrit name for the rosary is *japamala*, "muttering chaplet," and sometimes *smarana*, "remembrancer." Corresponding to the two great religious sects into which the Hindus are mainly divided there are two rosaries, different in material and number of beads used by them. The rosary of the votaries of Siva is a string of 32 or 64 rough berries of the *rudraksha* tree (*Elacocarpus ganitrus*) each generally marked with five lines, the roughness perhaps symbolizing the austerities connected with the worship of Siva, and the five lines standing for the five faces, or the five distinct aspects of the god. That of the followers of Vishnu is usually made of the wood of the tulasi, or holy basil (*Ocimum sanctum*), a shrub sacred to Vishnu,<sup>d</sup> and generally consists of 108 smooth beads. Hindu ascetics (*yogis*) are said to sometimes wear beads made of the teeth of dead bodies. The rosary is used by the Hindus to count the repetition of the names and epithets

<sup>a</sup> A. V. Williams Jackson, *Persia, Past and Present*, New York, 1906, p. 395, mentions that in connection with the funerary rites of the Parsees, or Zoroastrians in Persia, "The priest, with a rosary of beads, asks each of the mourners how many prayers he will offer in memory of the deceased." But nothing further could be learned on the nature and use of the Parsee rosary.

<sup>b</sup> The *Athenæum*, February 9, 1878, p. 188.

<sup>c</sup> Compare E. Washburn Hopkins, *The Religions of India*, Boston and London, 1895, p. 557.

<sup>d</sup> "The tulasi shrub is pervaded by the essence of the great god Vishnu and his wife Lakshmi, and is itself worshipped daily as a deity." J. G. Frazer, *Lectures on the Early History of Kingship*, London, 1905, p. 156.



of the deity. High-caste Brahmans merely employ it to assist them in counting up their daily prayers, while the ascetics consider the operation of counting a means of promoting contemplation and mental abstraction, which is so highly prized by the Hindus. Devotees attach great importance to the size of the beads, which may vary from small seeds to heavy balls as big as a human skull. Rosaries are also worn by the Hindus as necklaces, and the Vishnu chaplet of 108 tulasi beads plays an important part in the ceremony of confirmation, or initiation, which children undergo at the age of 6 or 7, when such a rosary is passed around their neck, and they are at the same time taught some sacred formula or sentence to be recited by them. There is no example of a Brahman rosary in the National Museum's collection. But in form and use it resembles the Buddhist rosary, of which it apparently was the parent.

## II. THE BUDDHIST ROSARY.

In the Buddhist rosary of 108 smooth beads may be recognized its Brahman origin. In fact, the rosary and even prayer itself, must be considered an accretion upon the simple original system of Buddha, in which "personal divinity has almost faded into a mere metaphysical idea." The rosary in Buddhism is accordingly especially peculiar to the northern school (the Mahayana, or great vehicle), with its belief in the merit and efficacy of meditation, and in the potency of repeating mystic spells and formulas. But, though thus borrowed from the outside, the rosary has attained in Buddhism its widest diffusion and most general application. It forms an essential part of a Buddhist monk's equipment.

The Buddhists give the number 108 of the beads a symbolic signification of their own: The number 108 is said to correspond to a like number of mental conditions, or sinful inclinations, which are to be overcome by the recitation of the beads.<sup>a</sup> The number 108 seems to have a special signification in the tradition and philosophy of Buddhism; 108 Brahmans were summoned at Buddha's birth to foretell his destiny. The Burmese foot prints of Buddha have sometimes 108 subdivisions; the *Kahgyur*, the Tibetan sacred writings of Buddhism, are composed of 108 volumes, and the white pagoda at Peking is surrounded by 108 columns. So also in Japan, on the festival of the dead (the *bommatsuri* or *bonku*), which is observed from the 13th to the 15th of July, 108 welcome fires (*mukaebi*) are

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<sup>a</sup> In the Buddhist Forty-two Points of Doctrine, article 10, is written: "The man, who in the practice of virtue applies himself to the extirpation of all his vices, is like to one who is rolling between his fingers the beads of a chaplet. If he continues taking hold of them one by one he arrives speedily at the end. By extirpating his bad inclinations one by one a man arrives thus at perfection." Compare Dr. Zerfii in Journ. Soc. Arts, May 9, 1873, p. 469.

lighted along the shores of the sea or lake or river by which a city or village is situated.<sup>a</sup> One hundred and eight rupees are commonly given in alms, while in China 108 blows are an ordinary punishment for malefactors.

Alongside of the full rosary of 108 beads, employed by the monks, there are in vogue rosaries of 18 and 16 beads, representing, respectively, the 18 *lohas*, or chief disciples of Buddha counted by the Chinese, and the 16 *rohans* of the Japanese. The common people, moreover, use indifferently rosaries of 30 or 40 beads.

The material of the Buddhist rosaries varies according to the taste, wealth, and rank of the owner. The commonest are made of seeds, wood, pebbles, shells, glass, or bone; the more costly of jade, turquoise, coral, amber, silver and gold, and even of pearls and other gems. Marco Polo relates that the king of Maabar (that is, Malabar), whom he visited about 1290 A. D., had a necklace of 104 (doubtless an error for 108) large pearls and rubies to count his prayers upon. Much in favor for rosary beads is the wood of the sacred Bo-tree (Indian Pilpal, a species of fig, *Ficus religiosa*), under which Sakya Muni attained to the state of Buddha.

The countries in which the Buddhist rosary is most widely used are Tibet, China, and Japan.<sup>b</sup>

#### A. TIBETAN ROSARIES.

The rosary in Tibet—called *tregwa*, "string of beads"—is not only an essential part of the outfit of the lamas, as the Buddhist monks are called there, but is everywhere in appearance. The patron god of Tibet, Cheresi or Padmapani, is represented with a rosary in his hand, and nearly every man and woman carries a rosary, holding it in the hand, or attached to the girdle, or wearing it around the neck as a necklace, or twisted around the wrist as a bracelet. Laymen also use it to assist in ordinary calculations, like the sliding balls of the Chinese, in their business transactions.

The material is not only varied according to the taste and wealth of the owner, but is also determined by the particular sect to which the devotee belongs, and the deity to whom worship is to be rendered. The head lama of a large and wealthy monastery may have rosaries

<sup>a</sup> Compare Lafcadio Hearn, *Glimpses of Unfamiliar Japan*, London, I, p. 107.

<sup>b</sup> As regards Burma, Mr. Waddell (*Journ. Asiat. Soc. Bengal*, LXI, p. 25) relates that he met several Burmese monks "possessed of a rosary, called 'Bodhi,' consisting of 72 black subcylindrical beads, which I understand were composed of slips of a leaf inscribed with charmed words and rolled into pellets with the aid of lacquer or varnish." He adds (p. 33) that the Burmese "seem to use their rosary for repeating the names of the Buddha Trinity, namely, Phra or Buddha, Tara or Dharma [law], and Sangha [the congregation], and the number of their beads in their rosary is a multiple of 3 by 3, as with the lamas."

of pearl and other precious stones, or of silver and gold. The yellow rosary made from the ochery yellow wood, supposed to be from the Bodhi tree, usually in form of spherical beads about the size of a pea, is used for all kinds of devotions. But prized above all are beads made from the bones of a holy lama. Lay people, however, use rosaries composed of any sort of bead, and the same chaplet may contain beads of a variety of sizes, materials, and colors.

The full Tibetan rosary of 108 beads is usually divided by three beads of a different size or material into four groups of 27 beads each. The two ends of the string before being knotted are passed through three extra beads, called *do dzin* (spelled *rdog hdzin*), "retaining beads" or "union holders," as they keep the proper rosary beads in position and indicate the completion of a cycle. They symbolize the Buddhist triad—the Buddha, the doctrine (*dharma*) and the community (*sangha*). Attached to the main string are two small pendant strings, having each 10 smaller beads, or metal rings, one terminating in a miniature *dorje* or *vajra* (the conventionalized thunderbolt of Indra), the other in a tiny bell (*drilbu*). These pendants are used as counters (*drang dzin*) to keep count of the number of times the rosary is said. A bead of the *dorje* string is slid down to mark a single recital of the rosary, while those of the bell string note each ten repetitions. They thus serve to register the utterance of 108 multiplied by 10 multiplied by 10 equaling 10,800 prayers or formulas. In the beads of lay people both counter strings record only units of cycles, which suffice for the smaller amount of bead telling done by the laity. Sometimes there are two additional pendants terminating respectively in a magic peg (*purbu*) and a wheel (*k'or lo*). There are also attached to the rosary string small odds and ends, such as keys, tweezers, toothpicks, etc.

The formula most frequently repeated by means of the rosary, and which is uttered at the conclusion of any other prayer that may be recited, is *Om mani padme hum!* which is commonly rendered "Salutation to the jewel in the lotus flower!" in allusion to Padmapani (Sanskrit Avalokiteshvara), the mystical reflex or representative of Buddha, who is believed to have appeared on earth from a lotus flower. He is held in special veneration in Tibet as the protector and patron of the country, and is believed to be reincarnated in the Dalai Lama, the head of Tibetan Buddhism, by the emission of a beam of light.

1. *Tibetan rosary*.—Consisting of 108 disk-shaped shell beads, divided into four groups of 27 beads each by three red coral beads. The three retaining beads are a large spherical amber bead, a smaller disk-shaped one, and a conical one of coral. The four counter strings, with 10 silver beads on each, terminate in various ornaments. This form of rosary is in common use among the lamas. Length,



25 inches. Kumbum, Tibet. (Plate 21, Cat. No. 167271, U.S.N.M.) Lent by Hon. W. W. Rockhill.<sup>a</sup>

2. *Tibetan rosary*.—Consisting of 108 disks cut from human skulls, divided into four sections of 27 each by three larger disks of conch shell, with two retaining beads of amber and wood, respectively, but without counters. Such rosaries are especially used in the worship of Dorje jig-ch'e (Sanskrit, Yama), the king of the dead. Length, 25 inches. Tibet. (Cat. No. 130387, U.S.N.M.) Lent by Hon. W. W. Rockhill.

3. *Tibetan rosary*.—Made of small disks of rosewood, with four red coral beads as dividers. It has no counters, and the dividing beads, as also the three retaining ones, have to be counted to complete the number of 108. Beads of reddish color, usually of red sandalwood, are used in the worship of the fierce Tamdrin, the special protector of Lamaism. Length, 15 inches. Ta-chien-lu, China. (Plate 22, fig. 1, Cat. No. 167267, U.S.N.M.). Lent by Hon. W. W. Rockhill.

4. *Tibetan rosary*.—The same as No. 3. Ta-chien-lu, China. (Cat. No. 167267, U.S.N.M.). Lent by Hon. W. W. Rockhill.

5. *Tibetan rosary*.—Consisting of 108 disks of yellow wood, with the dividing beads of the same material, only slightly larger and thicker. It has only two retaining beads and no counters. It is the special rosary of the Gelupa, or reformed school of lamaism. Length, 25 inches. Batang, China. (Plate 22, fig. 2, Cat. No. 131058, U.S.N.M.). Lent by Hon. W. W. Rockhill.

6. *Tibetan rosary*.—Consisting of 108 spherical beads of yellow wood, without counters and with only one retaining bead. Said to have been brought from Lhasa, the holy capital city of Tibet. Length, 39 inches. Ladakh, Tibet. (Cat. No. 178120, U.S.N.M.) Gift of Dr. W. L. Abbott.

7. *Tibetan rosary*.—The same as No. 6, only the beads are smaller in size. Length, 26 inches. Ladakh, Tibet. (Cat. No. 178119, U.S.N.M.) Gift of Dr. W. L. Abbott.

#### B. CHINESE ROSARIES.

The Chinese name for rosary is *su-chu*. The full or long rosary consists, like the Tibetan, of 108 beads, and is also usually divided by three beads of a different size or color into four groups. The shorter rosary has 18 beads, corresponding to the 18 chief disciples of Buddha, or *lohas*. The ends of the string are passed through two retaining beads, a large globular one and a smaller oblong or oval one. The large bead sometimes contains a sacred relic or charm.

<sup>a</sup> The rosaries lent by Mr. Rockhill have also been described by their owner in Notes on the Ethnology of Tibet, by William Woodville Rockhill, in the Report of the U. S. National Museum for 1893, pp. 736-738 and pls. 35-37.



The Chinese official necklace, worn by dignitaries on state occasions, is the Buddhist rosary which was made a part of the court costume. These official *su-chus* are often made of costly materials and adorned with fine carvings. They are here represented by the following two numbers.

8. *Chinese official "su-chu."*—The 108 beads of the main string are palm wood balls five-eighths of an inch in diameter. The dividing, as also retaining, beads are of silver, richly enameled, measuring  $1\frac{1}{8}$  inches in diameter. The three counter strings have each ten beads, likewise of enameled silver, but of smaller size, being only one-half inch in diameter. From the retaining beads is suspended a silk ribbon embroidered with small glass beads of diverse colors to represent the Swastika and other symbols, with a silver enameled medallion, measuring  $2\frac{1}{4}$  by  $1\frac{3}{4}$  inches, in the center, and terminating in an oblong or oval bead 2 inches long. Such an oval bead is also at the end of each of the three counter strings, each  $1\frac{1}{4}$  inches long. They are called the "four dewdrops," which they resemble, or the "disciple beads," or the "regents of the four heavens." They typify the emperor, father, mother, and the teacher to whom a Chinese subject owes reverence and obedience.<sup>a</sup> Length, 8 feet. China. (Plate 23, Cat. No. 202869, U.S.N.M.) Gift of Mr. Yang Yu, Chinese minister to the United States, 1897.

9. *Chinese official "su-chu."*—Made of glass beads. The 108 beads of the main string, five-eighths of an inch in diameter, are amber colored; the dividing and retaining beads, 1 inch in diameter, are green, while those on the counter strings and the medallion or disk on the pendant ribbon are of rose color. Length, 3 feet 8 inches. China. (Plate 24, Cat. No. 5559, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

10. *Chinese rosary.*—Consisting of 108 globular beads made of plum stones. Finely carved, so that on each bead, measuring one-half of an inch in diameter, are seen five human figures in the midst of flowers and trees. Length, 4 feet 7 inches. China. (Cat. No. 5526, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

11. *Chinese rosary.*—Consisting of 108 globular beads made of rhinoceros horn, terminating in two retaining beads and a tassel of white silk. Length, 4 feet 8 inches. China. (Cat. No. 5541, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

12. *Chinese rosary.*—Consisting of 108 globular beads made of ebony. Used by pilgrims. Length, 41 inches. China. (Cat. No. 5540, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

13. *Chinese rosary.*—Consisting of 108 ovoid beads made of ebony, with the dividing and retaining beads of reddish agate. Length, 40

<sup>a</sup> The information on the Chinese rosary is largely derived from Miss Scidmore's notes.

inches. China. (Cat. No. 5521, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

14. *Chinese rosary*.—Consisting of 108 globular beads made of polished palm wood, with the dividing and retaining beads of white glass. Length, 44 inches. China. (Cat. No. 5544, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

15. *Chinese rosary*.—Consisting of 108 pearl-colored glass beads; the dividing and retaining beads are green. Length, 35 inches. China. (Cat. No. 5522, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

16-18. *Three Chinese rosaries*.—Consisting each of 108 globular beads made of black wood. Length of each, 36 inches. Hoi-hau, China. (Cat. No. 154242, U.S.N.M.) Collected by Dr. Julius Neumann.

19. *Chinese rosary*.—Consisting of 18 olive-shaped beads, probably made of some wax or resin composition, each being carved into an image of one of the 18 *lo-hans*, or saints, with their special attributes. (See illustration to No. 50.) The term *lohan* (Japanese, *rohan*; Sanskrit, *arhant*) is applied to those disciples and followers of Buddha who have attained the highest degree of perfection. Length, 23 inches. China. (Cat. No. 130388, U.S.N.M.) Lent by Hon. W. W. Rockhill.

20. *Chinese rosary*.—Consisting of 18 peach-stone shaped beads, probably made of some wax composition. Each bead represents in low relief on one side the image of a *lohan* with his attribute, on the other the grotesque head of a demon. With two retaining beads of lapis lazuli and agate, respectively. Length, 17 inches. China. (Cat. No. 5513, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

21. *Chinese rosary*.—Consisting of 18 beads made in shape of walnut shells, but probably of some wax composition. On each bead is carved in low relief, on one side, the image of a *lohan*, on the other a Chinese inscription, perhaps the formula *Omito Fat* ("O, infinite Buddha!"), which is usually repeated by Chinese Buddhists on the rosary. With one retaining bead of agate. Length, 23 inches. China. (Cat. No. 5507, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

22. *Chinese rosary*.—Consisting of 18 beads made of plum stones, each carved into the head of a *lohan*. With one retaining bead of malachite. Length, 14½ inches. China. (Cat. No. 5508, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

23. *Chinese rosary*.—Consisting of 18 beads made of plum stones, cut into the form of vases with flowers. Length, 17 inches. China. (Cat. No. 5510, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

24. *Chinese rosary*.—Consisting of 18 beads made of peach stones, each finely carved in intaglio with the figure of a *lohan* with his special attribute, surrounded by flowers and trees. Length, 20 inches. China. (Cat. No. 5515, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

25. *Chinese rosary*.—Consisting of 18 beads made of peach stones, each cut into the form of the fish-shaped templed drum, called in Chinese *mo-yü*, in Japanese *mokugio*. Length, 19 inches. China. (Cat. No. 5509, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

26. *Chinese rosary*.—Consisting of 18 beads made of the dried and polished fruit of *Elaeocarpus*. Length, 18 inches. China. (Cat. No. 130403, U.S.N.M.) Lent by Hon. W. W. Rockhill.

27. *Chinese rosary*.—Consisting of 18 beads made of the fruit of the *Trapa bicornis* of China, which resembles a buffalo's head with two blunt horns. Length, 21 inches. China. (Cat. No. 5512, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

28. *Chinese rosary*.—Consisting of 18 oblong amber beads, with two retaining beads. Length, 17 inches. China. (Cat. No. 5503, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

29. *Chinese rosary*.—Consisting of 50 beads of alternating bone cylinders and oval blue glass pearls. Attached to the retaining bead is a lizard or marmot of jade. Length, 26 inches. China. (Cat. No. 5518, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

#### C. JAPANESE ROSARIES.

In the Japanese *jiu-dzu* the Buddhist rosary attained its highest development. The *sho-zoki jiu-dzu*, or the rosary used by all sects in common, consists of 112 beads of a uniform size, divided by two large beads, called *oya-dama*, or parent beads, into two equal parts. They are distinguished into upper parent bead, *ten-no oya-dama*, also called, father, sun, Buddha, etc., and lower parent bead, *chi-no oya-dama*, mother, moon, Bo, divine spirit, which inspired and perfected the enlightenment of Buddha. The ends of the string before being knotted are drawn through the two parent beads which have for this purpose a third opening. From the upper parent bead extend two pendent strings on which are strung 21 beads, rather smaller than those on the main string, in the following manner: Immediately above the large parent bead, on the left side pendent string, is a solitary bead. Beyond this the strings are knotted. Then come five beads on each string when they are again knotted. Still again there are another five beads on each pendant, which then terminates in an elongated bead, called dewdrop, *tsuyu-dama*. The use of the solitary bead is that in holding the rosary, with the upper parent bead uppermost, it should be in the left hand; this will insure a right signification to each bead during prayer. The collective name of these pendent beads is *kami-deshi*, superior disciples. Extending from the lower parent bead are three strings on two of which are five small beads, called *shima-deshi*, or inferior disciples, each terminating in a dewdrop bead, while the third has ten small beads, without a dewdrop. They are used as counters and are called



*hadzu-tori*. The four dewdrop beads are also termed *shi-ten-no*, the four regents who are supposed to preside over the four quarters of the universe. The rosary represents metaphorically the Buddhist pantheon; and the position of the four dewdrops at the ends of the strings on which all the other beads are strung, thus keeping in harmony and order the entire rosary as it is intended to be used, is supposed to be symbolic of their actual positions of power and authority in the universe.

On the main string, at an interval of seven beads on either side from the upper parent bead, are two beads, rather smaller than the others and generally of a different material, and again, at an interval of fourteen beads from these, on either side, are other two of the same kind. They are sometimes erroneously called *shi-ten-uo*, the four regents, or *shi-bosatsu*, the four saints. They indicate where a special invocation is to be uttered while the rosary is lifted to the forehead with a reverence.

A smaller rosary of 16 beads, corresponding to the 16 Japanese *rohans*, or chief disciples of Buddha (analogous to the 18 *lohans* of the Chinese), is chiefly used by lay people on ceremonial and social occasions. It has only one parent bead, or *oya-dama*, and one elongated, tapering bead in form of a vase or pagoda (similar to the retaining beads in the Tibetan rosary), called *fusa-dome*, "tassel stopper," and terminates in a silk tassel. Frequently it is spaced by two saints' or *busatsu* beads of a different substance. Moreover, the Japanese rosary varies in the number as well as the arrangement of the beads with the different sects.

The rosary, according to Miss Seidmore, who traveled extensively in Japan, plays an important part not only in the religious life but also in the social etiquette of Japan. It is carried by monks and lay people on all occasions of religious celebrations, on visits of ceremony or condolence, at funerals, etc. There is always a hook on the wall or on posts of the ceremonial or tea room, on which to hang the *jū-dzu*, and a unique or historic rosary is a much appreciated ornament for a tea room. Among the treasures of the Imperial Museum in Tokyo is the *jū-dzu* of the regent Shotoku Taishi, the Constantine of Buddhism in Japan, who died in 621 A. D. All the soldiers in the late Russo-Japanese war carried rosaries with them. The dead are always buried or cremated with a rosary slipped on the wrist, and the mourners in a funeral procession likewise carry each a rosary.

*Jū-dzu* shops, marked by a gigantic rosary on the outside, flourish at every place of popular pilgrimage and at some of the larger temples, and a rosary that has been consecrated over the sacred flame and incense smoke of a venerated temple is greatly valued by the devout.



30. *Japanese rosary*.—Consisting of 112 globular beads made of cherry wood. It is the *sho-zoki jiu-dzu* described above, which is used by all sects. The parent, disciple, regent, and saints' beads are of the same material, differing only in size. Length, 6 feet 6 inches. Japan. (Cat. No. 130, 683, U.S.N.M.) Collected by Mr. Romyn Hitchcock.

31-32. *Two Japanese rosaries*.—Consisting each of 112 globular beads made of plum-tree wood. The same as the preceding No. 30. Length, 6 feet. Japan. (Cat. No. 130683, U.S.N.M.) Collected by Mr. Romyn Hitchcock.

33. *Japanese rosary*.—Consisting of 112 small globular beads made of cherry wood. Used by the Nichiren sect, which was founded in the middle of the thirteenth century A. D. Its rosary is similar to the *sho-zoki jiu dzu*, differing only in the size of the beads, which, as a rule, are very small for convenience of carrying and for being more easily manipulated. Length, 32 inches. Japan. (Cat. No. 5525, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

34. *Japanese rosary*.—Consisting of 112 beads made of mother of pearl. The two parent beads are of amber, the four spacing or saints' beads are of red coral. This rosary is used by the Shin-Gon sect, which was founded 805 A. D. Length, 4 feet. Japan. (Plate 25, fig. 1, Cat. No. 5555, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

35. *Japanese rosary*.—Consisting of 112 beads made of smooth peach stones. The beads on the pendant strings, as also the parent and spacing beads, are of glass. Length, 8 feet. Japan. (Cat. No. 5545, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

36. *Japanese rosary*.—Consisting of 112 beads of some dark-brown seeds, with the beads on the pendant strings and parent and spacing beads of glass. Length, 26 inches. Japan. (Cat. No. 5550, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

37. *Japanese rosary*.—Consisting of 112 flattened beads made of ebony. Used by the Zén sect, which was founded at the beginning of the thirteenth century A. D. This rosary has the two parent and four spacing or saints' beads, but no pendant strings with their disciple beads. The ends of the strings run out from the upper parent bead, extending about 4 inches in length and terminating in a knot without tassel. The four spacing or saints' beads are here placed at intervals of 18 beads, so that by means of the two parent and four saints' beads the string is divided into six sections of 18 beads each. The parent and saints' beads are of glass. Length, 28 inches. Japan. (Cat. No. 5528, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

38. *Japanese rosary*.—Consisting of 174 flattened beads made of black wood. The parent, pendant, and spacing beads are of glass. Perhaps used by the lay people of the Zen sect. Length, 6 feet.

Japan. (Cat. No. 5547, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

39. *Japanese rosary*.—Consisting of 100 flat beads made of plum-tree wood, without spacing beads. Length, 4 feet 10 inches. Japan. (Cat. No. 5519, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

40. *Japanese rosary*.—Consisting of 82 globular glass beads. The pendants of the lower parent bead are without beads. There are also wanting the spacing beads. Perhaps used by the Monto or Ikkoshin sect, which was founded at the beginning of the thirteenth century A. D. Length, 22 inches. Japan. (Cat. No. 5548, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

41. *Japanese rosary*.—Consisting of 80 beads made of the fruit of *Elaeocarpus*, dried and polished. At an interval of ten beads on either side of the parent beads are three smaller glass beads. The pendant strings have likewise glass beads. Length, 5 feet 3 inches. Japan. (Cat. No. 5543, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

42. *Japanese rosary*.—Consisting of 58 beads made of carved cherry stones. With one parent bead of glass followed by an elongated stopper bead (*fusa-dome*) of mother-of-pearl and terminating in a tassel formed of eight silk cords. The four spacing beads are of amber. Length, 24 inches. Japan. (Cat. No. 5517, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

43. *Japanese rosary*.—Consisting of 69 glass beads, without any attachments excepting two tassels. It was hung on the arm of a temple image in Kioto. Length, 25 inches. Japan. (Cat. No. 5535, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

44. *Japanese rosary*.—Consisting of 54 beads made of the nuts of the Pride of India (also known as tree of paradise, bead tree, or holy tree—*Melia azedarach*). The parent beads are of black wood, while those on the pendant strings are of glass. There are no dewdrops nor spacing beads. Length, 41 inches. Japan. (Cat. No. 5542, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

45. *Japanese rosary*.—Consisting of 100 beads of "Job's tears" (*Coix lachryma-jobi*), with only one pendant string from either parent bead, the other evidently having been worn off. Length, 4 feet. Japan. (Cat. No. 5534, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

46. *Japanese rosary*.—Consisting of 192 beads made of black wood. It is probably made up of two different strings, as the beads are of unequal size. At irregular intervals are two or three glass beads. From either of the parent beads extend two strings with tassels, but without beads. Length, 5 feet 4 inches. Japan. (Cat. No. 5539, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

47. *Japanese primitive necklace, so-called "Shinto rosary"*.—It consists of a string of 30 glass pieces in regular alternation of one

in form of the toe of a bear (the sacred animal of the Ainu), one of a globe, and the third of a tube or cylinder, with one of the latter serving as a tassel stopper (*fusa-dome*). Length, 25 inches. Japan. (Plate 25, fig. 2. Cat. No. 5520, U.S.N.M.) Lent by Miss Eliza R. Seidmore.

48. *Japanese rosary*.—Made of flattened mahogany beads peculiar to the Jodo sect, which was founded by Honen Shonin at the end of the twelfth century A. D. Its rosary consists of two strings of beads reeved one within the other. One usually has 40 flat beads with one parent bead; the other 27 of the same size as the 40, alternating with 28 smaller ones, and likewise one parent bead, thus making a total of 95 beads, exclusive of the two large parent beads. On the second larger string is a metal ring, sufficiently large to allow the string to pass freely through it. Attached to this ring are two pendant strings, on one of which are ten small round beads, on the other six, both terminating with dewdrop beads. On the smaller string of 40 beads the single prayers or formulas are recited, while the larger string of 55 and the two pendant strings with their 16 beads are used as two sets of counters in the following way: The string with 40 beads is placed, with the parent bead uppermost, over the first joint of the forefinger, while the other string with 55 beads is held between the second and third fingers of the same hand and used as a first set of counters. The upper string is then turned by the thumb, one bead at a time for each prayer or formula uttered, beginning with the bead next to the parent bead, until it comes round to its starting point, when one bead of the lower string, starting likewise from the parent bead, is slipped through between the fingers, one bead for every revolution of the upper string, until the whole has been exhausted, when recourse is had to one of the small pendant beads to register the fact. The whole process has then to be gone over again, so that by the time the whole of the 16 beads has been used 35,200 prayers will have been recited.

The invention of this double rosary is ascribed to Awanosuke, one of the personal attendants of the founder of the Jodo sect, its object being that it should be manipulated only with the left hand, thereby leaving the right hand free to minister to the needs of his master, thus combining praying and working at one and the same time. In the present example the upper string has 36 and the lower 30 beads, all of the same size. Length, 28 inches. Japan. (Plate 26, fig. 1. Cat. No. 5527, U.S.N.M.) Lent by Miss Eliza R. Seidmore.

49. *Japanese rosary*.—Consisting of 18 beads made of walnut shells cut in the shape of skulls. Upon the parent bead are carved two groups of nine figures each, representing the 18 disciples (*rohans*). The tassel stopper is of mother-of-pearl. The two cords which extend from the parent bead are tied with three peculiar knots.



Length, 27 inches. Japan. (Plate 26, fig. 2. Cat. No. 5516, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

50. *Japanese rosary*.—Consisting of 12 olive-shaped beads, probably made of some wax or resin composition, each being carved into an image of a saint, with his special attribute (compare above No. 19). The parent bead and tassel stopper are of jade. Length, 27 inches. Japan. (Plate 26, fig. 3. Cat. No. 5505, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

51. *Japanese rosary*.—Consisting of 16 beads of the same material and workmanship as those of No. 50. The parent bead, the tassel stopper, and two spacing beads are of agate. Length, 21 inches. Japan. (Cat. No. 5504, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

52. *Japanese rosary*.—Consisting of 16 beads in shape of walnut shells, but probably made of some wax composition. On each bead is carved in low relief, on one side, the image of a saint, on the other, some animal or bird. The tassel stopper is of agate. Length, 28 inches. Japan. (Cat. No. 5506, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

53. *Japanese rosary*.—Consisting of 18 beads of plum stones. On each are finely carved in intaglio four human figures, surmounted by an open lotus flower and surrounded by plants and animals. The parent bead is of amber, while the tassel stopper and two spacing beads are of glass. Length, 22 inches. Japan. (Cat. No. 5511, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

54. *Japanese rosary*.—Consisting of 27 beads of smooth plum stones. The parent bead and two spacing beads are of white glass, while the tassel stopper is of green glass. Length, 18 inches. Japan. (Cat. No. 5551, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

55. *Japanese rosary*.—Consisting of 26 beads of smooth plum stones. The two spacing beads and the tassel stopper are of green glass. Length, 18 inches. Japan. (Cat. No. 5552, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

56. *Japanese rosary*.—Consisting of 21 beads of smooth plum stones, with four spacing beads of pink-colored glass. Length, 21 inches. Japan. (Cat. No. 5529, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

57. *Japanese rosary*.—Consisting of 21 beads of smooth plum stones. The parent bead is of white glass, the tassel stopper of bone, and the two dividing beads are of green glass. Length, 15 inches. Japan. (Cat. No. 5531, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

58. *Japanese rosary*.—Consisting of 20 beads of the fruit of *Elaeocarpus*, dried and polished. The parent bead and tassel stopper are of porcelain, while the two spacing beads are of amber. Length, 12 inches. Japan. (Cat. No. 5549, U.S.N.M.) Lent by Miss Eliza R. Scidmore.



59. *Japanese rosary*.—Consisting of 18 beads made of palm nuts. The parent bead is of glass, the tassel stopper of mother-of-pearl. Length, 26 inches. Japan. (Cat. No. 5530, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

60. *Japanese rosary*.—Consisting of 18 beads made of palm nuts. The parent bead and the spacing beads are of glass, while the tassel stopper is of porcelain. Length, 20 inches. Japan. (Cat. No. 5538, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

61. *Japanese rosary*.—Consisting of 16 beads made of palm nuts. The parent bead and tassel stopper are of porcelain, the two spacing beads of yellow glass. Length, 15 inches. Japan. (Cat. No. 5536, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

62. *Japanese rosary*.—Consisting of 27 beads made of cumuna pods. The two spacing beads are of reddish agate, the parent bead is of glass, and the tassel stopper of bone. Length, 13½ inches. Japan. (Cat. No. 5537, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

63. *Japanese rosary*.—Consisting of 27 beads made of dwarfed peach stones, with the parent bead of black wood. Length, 13 inches. Japan. (Cat. No. 5533, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

64. *Japanese rosary*.—Consisting of 20 beads of the berries of Pride of India (*Melia azedarach*). The parent bead and tassel stopper are of porcelain, the two dividing beads are of glass. Length, 12 inches. Japan. (Cat. No. 5554, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

65. *Japanese rosary*.—Consisting of 20 beads of the berries of Pride of India (*Melia azedarach*), with one parent bead of glass. Length, 13 inches. Japan. (Cat. No. 5532, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

66. *Japanese rosary*.—Consisting of 19 beads of pine nuts. The parent bead is of glass, the tassel stopper of bone. Length, 17 inches. Japan. (Cat. No. 5502, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

67. *Japanese rosary*.—Consisting of 18 beads made up of various fruits, nuts, and berries, with two parent beads of fruit and tassel stopper of bone. Length, 23 inches. Japan. (Cat. No. 5553, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

68. *Japanese rosary*.—Consisting of 34 globular beads made of red wood. The two spacing beads and the parent bead are of glass, while the tassel stopper is of horn. Length, 19 inches. Japan. (Cat. No. 5546, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

69. *Japanese rosary*.—Consisting of 23 beads of alternating wooden models of a pagoda and beads of mother-of-pearl, quartz, and glass, with parent bead and tassel stopper of agate. Length, 12 inches.

Japan. (Cat. No. 5514, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

70. *Japanese funeral rosary from the Senkoji temple.*—Consisting of 11 cylindrical wooden beads roughly cut. It is worn around the wrist by mourners at a funeral. Length, 9 inches. Japan. (Cat. No. 5501, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

71. *Japanese rosary.*—Used for the *Hiaku mam-ben* devotion, when the formula, *Namu Amida Butsu!*, "Hail, infinite Buddha!" (shortened into *Nem-butso!*), which the Japanese usually repeat by means of the rosary, is recited a million times. This special devotion was instituted in Kioto in 1331 A. D., on the occasion of a devastating plague, and its celebration is reserved for times of calamity, such as pestilence, war, and famine. At certain popular temples, however, it is almost continually observed by the pilgrims. For this service a rosary of 1,008 large wooden beads is used. The present specimen consists of 897 flat wooden beads, with 2 parent beads, from one of which extend 2 pendent strings with 5 smaller beads on each. Length, 20 feet. Japan. (Cat. No. 5556, U.S.N.M.) Lent by Miss Eliza R. Scidmore.

### III. THE MOHAMMEDAN ROSARY.

The Mohammedan rosary, called *subha*, in Persia, *tasbeih* (from the Arabic verb *sabbaha*, "to praise," "to exalt"), consists of 99 beads, divided into three equal portions by a stone or bead of different shape or, in the more costly varieties, by tassels, called *shamsa* ("servant"), made of gold thread or variegated silk. The Mohammedans use the rosary for the recital of the 99 attributes of God, as, "the mighty" (*al-aziz*), "the holy" (*al-kuddus*), "the merciful" (*ar-rahman*), "the loving" (*al-wadud*), "the forgiver" (*al-ghafar*), etc. A hundredth bead of larger size, called the *imam* ("leader"), or a tassel in its place, is frequently added for the essential name of God, *Allah*.<sup>a</sup> Other devotional formulas recited by means of the rosary, are the ejaculations known as the *takbir*: "God is very great" (*Allahu akbar*); the *tasbeih*: "I extol God" (*subhana illah*); the *tahmid*: "God be praised" (*al-hamdu l'illahi*), and the *tahlil*: "There is no deity but God" (*la ilaha illa illah*). Great merit, according to tradition, is attributed by the prophet to the recital of the hundred names of God, or to the repetition of these formulas. "Verily," he is reported to have said, "there are ninety-nine names of God, and whoever recites them shall enter into Paradise," and "Whoever recites this sentence (the *tasbeih* and *tahmid*) a hundred times, morning and evening, will have all his sins forgiven."

<sup>a</sup> According to Mr. R. A. Stewart Macalister, in the Palestine Exploration Fund Quarterly Statement for July, 1908, p. 172, "There is another variety of rosary less commonly used, with 101 pellets corresponding to the 101 names of the Prophet."

Mohammedan rosaries are frequently made of date stones. Special value is attached to beads, the material of which originated in the sacred cities of Mecca and Medina.

It is generally assumed that the Mohammedans borrowed the rosary full-grown from the Buddhists. The Mohammedan tradition (*hadith*) pushes back the use of some mechanical contrivance for counting prayers to the time of Mohammed. It is related that the prophet reproached some women for using pebbles in repeating the *tasbih*, *takbir*, etc., and recommended that they should count them on their fingers. In a tradition, collected in the third century A. H. (ninth century A. D.), is related that Abu Abd al-Rahman, son of Abu Bekr, the first calif, who died about 53 A. H. (673 A. D.), seeing in the mosque groups of worshipers, reciting under a leader 100 *takbirs*, 100 *takhlils*, and 100 *tasbihs* by means of small pebbles, reproached them with the words, "Rather count your sins, and I shall guarantee you that nothing of your good works will be lost." Abdallah, son of the calif Omar, who died 73 A. H. (692 A. D.), seeing one picking up pebbles while praying, said to him, "Do not do that, for this comes from Satan." All this may point to the adoption of some counting device at the time when the recitation of the above-mentioned formulas became a practice, the date of which, however, can not be fixed with certainty. The use of pebbles in the repetition of these litanies would seem to mark a primitive form of the *subha*, the point of departure in the evolution which resulted in the rosary, that is, in threading beads on a string, which may have been copied from the Buddhists. It also shows that the rosary at the time of its appearance met with some opposition from the conservatives and the rigorists of the religious discipline. In fact, as late as the third century A. H. (ninth century A. D.) the use of the *subha*, as an instrument of prayer, was in vogue only among the lower classes and looked down upon by the theologians and higher classes. When the pious ascetic Abu-l-Kassim al-Gunejd (died 279 A. H.—909 A. D.) was found with a rosary and expostulated with, since he "belonged to the better world," he apologized with the words, "I could not renounce an object which was the means of bringing me nearer to God." Even in the seventh century A. H. (thirteenth A. D.) Abu Abdallah Mammed al-Abdari, called Ibn al-Hajj (died 737 A. H.—1336 A. D.), complains over the exaggerated use and esteem of the *subha* as being contrary to the primitive simplicity of Islam.

The Wahabis, followers of the reformer Abd al-Wahhab (1691–1787 A. D.), who opposed all practices not sanctioned by the Koran and tradition, regard the rosary as an abomination and count the names of God on their fingers.

72. *Mohammedan rosary*.—Consisting of 100 globular beads made of olive wood, divided into three sections by two vase or bottle-



shaped beads. The two ends of the string pass first through the hundredth bead, then through a fusiform or spindle-shaped tube, and lastly through two smaller beads, terminating in a green tassel. Length, 40 inches. Cairo, Egypt. (Plate 27, fig. 1. Cat. No. 155166, U.S.N.M.)

*73. Mohammedan rosary.*—Consisting of 97 beads made of blood-stones, with two dividing beads of chalcedony. Between the ninth and tenth beads from one end of the string an oblong rectangular piece of chalcedony is inserted, probably to complete, with the two dividers, the number 100. The string terminates in a tassel of silk and gold thread tied with an artistic knot. Length, 34 inches. (Plate 27, fig. 2. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

*74. Mohammedan rosary.*—Consisting of 91 beads made of horn. On either side of the two dividing beads, which are vase shaped and inlaid with silver dots, are three coral beads, and at either end of the string two coral and one amber beads. The ends of the string pass through two small beads of horn and a fusiform tube, terminating in a green tassel. Length, 31 inches. (Plate 27, fig. 3. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

*75. Mohammedan rosary.*—Consisting of 102 beads made of composition, alternating three brown-colored and one, somewhat larger, black. Length, 5 feet. Monastery of Mount Sinai, Syria. (Plate 27, fig. 4. Cat. No. 154561, U.S.N.M.) Gift of Mrs. Layyah Barakkah.

*76. Mohammedan rosary.*—Consisting of 100 beads made of black wood, divided into three sections by two beads of bone. The ends of the string are passed through an oblong piece of slate. Length, 45 inches. Paris, France. (Cat. No. 76709, U.S.N.M.) Collected by Mr. John Durand.

*77. Mohammedan rosary.*—Consisting of 99 beads made of bone, divided into three sections by two date stones. The ends of the string pass through a large bead made from a piece of conch shell. This style of rosary is used by the Mohammedans in China. Length, 30 inches. China. (Plate 22, fig. 3. Cat. No. 167300, U.S.N.M.) Lent by Hon. W. W. Rockhill.

#### IV. THE ROMAN CATHOLIC ROSARY.

The ordinary Catholic rosary consists of 150 small beads divided into decades by 15 larger beads. To these beads, forming a chaplet, is usually attached a pendant, consisting of a cross, one large and three small beads. The devotion begins with the invocation, "In the name of the Father, the Son, and the Holy Ghost." Then the Apostles' Creed is recited on the cross, a pater noster (the Lord's prayer) on the larger bead and three Ave Maria (Hail Mary) on the three smaller beads, closing with the gloria (Glory be to the



Father, etc.). This forms the introduction to the rosary proper. Then follow decades of aves, counted by the smaller beads, each decade preceded by a pater noster, for which a larger bead is used, and followed by a gloria. The 150 aves correspond to the number of Psalms, hence from an early period the devotion was called "Our Lady's psalter." For each decade a subject, or "mystery," in the life of Christ and Mary is set for meditation, the 15 mysteries being divided into 5 joyful, 5 sorrowful, and 5 glorious. The 5 joyful mysteries are: the annunciation (Luke i, 26), the visitation (Luke i, 39), the nativity (Luke ii), the presentation (Luke ii, 21), and the finding in the temple (Luke ii, 41); the 5 sorrowful mysteries are: the agony in the garden (Matthew xxvi, 36), the scourging (Matthew xxvii, 26), the crowning with thorns (Matthew xxvii, 29), the carrying of the cross (John xix, 17), and the crucifixion (Matthew xxvii, 35); the 5 glorious mysteries are: the resurrection (Matthew xxviii), the ascension (Luke xxiv, 50), the descent of the Holy Ghost (Acts ii), the assumption of Mary into heaven, and the coronation of Mary in heaven (the two last mysteries are accepted on the authority of tradition). This arrangement of definite mysteries does not occur prior to the fifteenth century. The earlier and more widely accepted practice was to assign an incident of Christ's life to each ave and to insert some short clause, commemorating the incident, into the ave itself. The rosary most in use, however, consists of five decades of small beads for the aves and five larger beads for the pater nosters, called the "lesser rosary." Otherwise it is arranged in the same way and recited in the same manner and order as the "greater" or "full" rosary. The entire devotion of 15 decades may be said on it by counting it three times.<sup>a</sup>

Rosaries are usually blessed with prayers and holy water by some duly authorized ecclesiastical person and become thereby sacramentals, that is, instruments of grace.<sup>b</sup>

The name "rosary" (Middle Latin, *rosarium*), which came in vogue for the devotion, and the string of beads by which it is per-

<sup>a</sup> In a rosary book entitled: *Jesus, Maria, Joseph* (dated 1663), the 15 mysteries are comprehended in the following three verses:

She's told, she visits, He's born, offered, found,  
He prays, is whipped, is crowned, carries, is killed,  
Rises, ascends, sends down: she dies, is crowned.

<sup>b</sup> Outside of the Roman Catholic Church, rosaries are in use among the Copts in Egypt. They generally consist of 42 beads, or sometimes of 81, and are employed to count the repetitions of the *Kyrie eleison* (Lord, have mercy upon us!). Compare Alfred J. Butler, *The Ancient Coptic Church of Egypt*, Oxford, 1884, II. p. 238. In the Orthodox Church when a novice is consecrated into the "second grade of monastic life," he is given, among other things, a chaplet (called in Russian, *chotki*, in Greek, *kombologion*, or *proscukhe*) to count prayers and protestations by. Compare D. Sokolof, *A manual of the Orthodox Churches*, New York and Albany, 1899, p. 151.

formed since the fifteenth century, is commonly explained as a metaphorical designation, meaning a wreath or chaplet of spiritual roses. The corresponding words, *corona*, chaplet, *Rosenkranz*, *capellina*, all convey the idea of a garland. Garlands of flowers were much worn at that period, and it was also the custom to place such garlands as a mark of respect or admiration upon the heads of persons or statues.<sup>a</sup> *Rosarium* was also not uncommonly used (like *florilegium*) in the sense of an anthology, or a collection of choice extracts. Others trace the name to the title "Mystical Rose," by which Mary is addressed in the litany of Loretto, or to the beads being originally made, commonly, of rosewood. In the middle ages many other names were applied to prayer beads, as pater noster beads, *patriloquium*, *devotiones*, *precaria*, *precula* (little prayers), *serta* (chaplets), *numeralia*, *calcula*, *computum* (counters), *signacula* (marks), etc. The word "bead" (beade or bedede) originally meant a prayer: to "bid the beads" and to "pray" were synonymous. The expression "bedes bydding" is found in the Vision of Piers the Plowman. So, also, Spenser in his *Faerie Queene*:

All night she spent in bidding of her bedes  
And all the day in doing good and Godly deeds.

In a bull of 1571 Pope Pius V (1566-1572) ascribes the invention of the "rosary, or Psalter of the Blessed Virgin," to St. Dominic (1170-1231), the founder of the Dominican order. This has been commonly understood of the string of beads, and the natural inference would be that the suggestion came to western Europe through the crusaders, who observed the Mohammedans using their *subha*. Legend has it that the Virgin Mary handed St. Dominic a rosary from heaven as a weapon against the Albigense heresy and the in-

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<sup>a</sup> A pretty story of a garland which is met with since the beginning of the thirteenth century, and with which the Rev. Herbert Thurston, in the *Scientific American*, already quoted, would connect the name "rosary," may find here a place. The legend, as given by Father Thurston, is this: "A youth was accustomed to make a wreath of roses or other flowers every day and to place it upon the head of Our Lady's statue. He became a monk, and in the cloister his occupations no longer permitted him to observe this pious practice. Being much distressed, he asked counsel of an aged priest, who advised him to say 50 aves every evening (in some versions it is 150, in others 25), which would be accepted by Our Lady in lieu of the garland. This the young man faithfully observed until one day, being upon a journey, he had to pass through a lonely wood where robbers were lying in wait. They were employed in watching him, feeling sure of their prey, when he, unsuspecting of their presence, remembered that his aves were not yet said and forthwith stopped to say them. Then to their surprise the robbers saw a most glorious lady stand before him and take one after another from the lips of the kneeling monk 50 beautiful roses, which she wove into a garland and placed upon her head. The robbers, so the legend tells, conscience stricken at the vision, were all converted to a better life, and themselves soon after entered the monastery."

fidels.<sup>a</sup> But both the practice of often repeating prayers and the employment of some device for recording the number of repetitions can be traced to a much earlier date, so that St. Dominic can only be considered as the originator and propagator of the present form of the rosary and the method of devotion (150 aves and 15 pater nosters). Thus Sozomenus (about 400–450) relates in his ecclesiastical history (book vi, chapter 29) that the Egyptian abbot Paul, who died in 341, recited daily 300 prayers which he counted by pebbles gathered in his cloak, dropping one as he finished each of the prayers. The same means for reckoning prayers is related to have been used by St. Godoric, an English saint who died in 1172. The first undoubted mention of the use of a string of beads for counting prayers is that of Lady Godiva, wife of Leofric, in the eleventh century, who, when dying, bequeathed to the monastery of Coventry, which was founded by her, “a circlet of gems, which she had threaded on a string, in order that by fingering them one by one, as she successively recited her prayers, she might not fall short of the exact number.”<sup>b</sup> The practice of repeating the same prayer a number of times, often amounting to more than a hundred, must have spontaneously led to the adoption of some contrivance for keeping an accurate record. It would seem, therefore, that though the Buddhist and Mohammedan varieties of bead chaplets preceded the Christian in order of time, there is not necessarily a causal connection between them.

As regards the arrangement of the chaplet into 50 or 150 beads, divided into decades, the total number of 150 corresponds, as mentioned above, to the number of Psalms. For the recital of a certain number of pater nosters, which was originally the prayer repeated on the chaplet, as its designation, pater noster beads, in nearly all European languages proves, was a substitute for the Psalms for those monks who had not sufficient education to learn them in Latin. Just as the Psalms were divided into fifties, so that the recitation of 50 or two fifties or three fifties was a common form of devotion, it was natural that 50 paters, or twice or thrice 50, should be enjoined on those who could not read. And as many still used the fingers to count with it was natural to subdivide the beads into tenths.

<sup>a</sup> In his encyclical of September 2, 1883, Leo XIII attributes to the power of the devotion of the rosary the suppression of the Albigense heresy in the twelfth and thirteenth centuries, the victory of the Christians over the Turks in the naval battle at Lepanto, near the Echinades Islands, on October 7, 1571, as also in the battle at Temesvar in Panonia and at Corfu in 1716. After the victory of John of Austria over the Turkish fleet at Lepanto Pius V established the festival of “Our Lady of Victory,” which Gregory XIII (1572–1582) two years later changed to the feast of the rosary, which since then has been observed on the first Sunday of October as the anniversary of the battle at Lepanto.

<sup>b</sup> William of Malmesbury, *Gesta Pontificum Anglicorum*, book iv, chapter 2, edition of 1596.



The number and arrangement of the beads were, however, not always uniform. Representations on tombs from the fourteenth to the sixteenth centuries exhibit rosaries divided into nines, sevens, sixes, and fives. On some the chaplets count 80, 75, 40, or 33 beads, often without divisions of any kind.

Besides the "Dominican" rosary, or the "Marian Psalter," described above, which is used in common by all Catholics, there are other varieties of chaplets used by particular religious bodies, or for special devotions. So the chaplet of St. Bridget of Sweden, which consists of 63 beads for the aves, to commemorate the 63 years which Mary is supposed to have lived, divided by seven beads for the pater, the crown of Our Lady, in use among the Franciscans, has 72 aves, based on another tradition of Mary's age, and others more.

During the middle ages the patenôtriers, paternosterers, i. e., makers of rosaries, represented an important branch of industry. In London a street, Paternoster lane, was called after them. In Rome there is still a street, near St. Peters, called Via Dei Coronari—corona being a variety of pater noster, or rosary. The existence of the name in various countries shows that the production of the rosary was a matter of commercial importance. Considerable artistic skill and costly material went into the manufacture of these instruments of piety, which were also worn as personal ornaments. In the inventory of the plate and jewels of Charles V, King of France, in 1380, there are enumerated 19 rosaries made of rose-tinted amber, jet, coral with pearls for markers (*seignault*), gold beads, rings of gold, blue and white enamel, jet beads with eleven gold crosslets (*croizettes*), black amber and pearls, coral alternating with beads of silver, and two instances of gold beads of Damascus work which were filled with musk. So, again, in the inventory of the Princess of Orleans, Valois, in 1408, there are entered a rosary of amethysts and jasper with a stud (*bouton*) of pearls, another of jet with nine little bells (*dandins*) of gold and a jewel with nine pearls as a pendant, and another again of jet with nine gold markers and a gold figurine of St. Christopher attached. Analogous to the attachment of keys, tweezers, etc., to the Tibetan rosary, various objects, such as signet rings, cameos, brooches were often suspended from the Christian rosary in the middle ages. As a consequence a certain worldliness and extravagance entered into the use of these objects of devotion, which the authorities tried to check. Thus the municipal council of Regensburg, in 1485, decreed that none should possess more than three or four rosaries, and that these should not exceed the value of 10 gulden.<sup>a</sup> And various monastic

<sup>a</sup> Compare Johannes Janssen, *Geschichte des deutschen Volkes seit dem Ausgang des Mittelalters*, Freiburg i. B., I. 8th edition, 1883, p. 377. Janssen adds: "As three fat oxen could then be purchased for 12 gulden, this seems a pretty generous allowance."



ordinances are extant prohibiting monks from having beads of coral, crystal, amber, etc., and nuns from wearing beads around their necks. On the other hand, beads were openly carried as a sign of penance, especially by bands of pilgrims visiting in procession the shrines, churches, and other holy places of Rome, and wearing of the beads at one's girdle was a distinctive sign of membership in a religious confraternity. The religious military orders, notably the Knights of St. John (founded in the twelfth century), adopted the rosary as part of the equipment of the lay members, who were required by their constitution to say 150 paters each day.

By the devout beads were especially valued if they had been worn by a person of known sanctity, or if they had touched the relics of some saint, in which case they were believed to be the instruments of miraculous power and healing virtue. The oriental Christians affect rosaries made in Jerusalem and other holy places of Palestine.

Another contrivance for counting prayers in the middle ages was the so-called "decade rings," or "rosary rings." They were finger rings having ten knobs, or bosses, at intervals all around a hoop; some had an eleventh knob of larger size, indicating ten aves and one pater. An additional twelfth knob marked the repetition of the Creed. Sometimes the knobs were separated from one another by three small beaded dots, perhaps symbolic of the Trinity. They were worn by some classes of the religious during the hours of repose, so that on awakening during the night they might repeat a certain number of prayers, marking them by the beads or knobs on the ring.<sup>a</sup>

78. *Catholic rosary*.—The full or greater Dominican rosary of 15 decades of beads for the aves and 15 larger ones for the paters are made of ebony. The cross, of the same material, is framed in silver-plated nickel, with the figure of Christ on one side and a crown of thorns with a burning heart inside, of the same metal, on the other. Length, 6 feet 9½ inches. (Plate 28, fig. 1. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

79. *Catholic rosary*.—The full or greater Dominican rosary. The beads for the aves are of glass, while those of the paters, as also the three introductory beads are of composition. Length, 4 feet 4 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

80. *Catholic rosary*.—The lesser Dominican rosary of five decades of beads for the aves and five larger beads for the paters, made of mahogany, with four sets of double circles, or "eyes," carved on each. The cross is likewise formed of beads. Length, 5 feet 3 inches. (Plate 28, fig. 2. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

<sup>a</sup> Compare William Jones, *Finger-ring Lore*. Historical, Legendary, Anecdotal, London, 1890, pp. 248–253.

81. *Catholic rosary*.—The lesser Dominican rosary of five decades of beads made of ebony, with the cross of the same material. Length, 4 feet 9 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

82. *Catholic rosary*.—The lesser Dominican rosary of five decades of very large oval beads coarsely made of wood, probably worn by some religious orders, perhaps Franciscans, at the girdle. Length, 4 feet 5 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

83. *Catholic rosary*.—The lesser Dominican rosary of five decades of beads made of olive wood, carved with intersecting circles. In place of the cross is a bronze medal, three-fourths of an inch in diameter, with the bust of Pius IX and the date 24 (the number of years of his reign) on the obverse; on the reverse is the figure of the Pope, in full pontificals, on his throne, attended by cardinals, and the Latin words, "Ecumenical Council, 1869," referring to the Vatican Council, which was opened in that year. This rosary was blessed by Pius IX in 1873. Length, 37 inches. Rome, Italy. (Plate 29, fig. 1. Cat. No. 168294, U.S.N.M.) Collected by Gen. John A. Halderman.

84. *Catholic rosary*.—The lesser Dominican rosary of pearl-colored glass beads. The place of the pater beads is taken by oval metal plaques engraved with the image of Mary and an invocation to her. It has no introductory beads. Length, 28 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

85. *Catholic rosary*.—The lesser Dominican rosary of black glass beads, rose cut. Length, 26 inches. Philippine Islands. (Cat. No. 205535, U.S.N.M.) Collected by Mr. A. J. Gies.

86. *Catholic rosary*.—The lesser Dominican rosary of ivory beads, faceted, while the pater beads are barrel shaped. In place of the cross is a copper medal, 1½ inches in diameter, having on the obverse the image of Mary crowned, with the infant Jesus in her arms; on the reverse, a much-effaced Latin inscription. Length, 40 inches. (Plate 29, fig. 2. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

87. *Catholic rosary*.—The lesser Dominican rosary of Job's tears. The cross of ebony is set in brass and has the same appurtenances as the one described under No. 78. Length, 33 inches. (Plate 29, fig. 3. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

88. *Catholic rosary*.—Consisting of seven sets, each having seven beads, made of composition. This rosary is used in honor of the seven sorrows of Mary, namely, the prophecy of Simon (Luke ii, 35); the flight into Egypt (Matthew ii, 13); the losing of Jesus in the

temple (Luke ii, 48) ; seeing Jesus carrying the cross (John xix, 17) ; standing under the cross (John xix, 25) ; the piercing of Jesus's side with the lance (John xix, 34), and the lowering of Jesus's body into the sepulcher (Matthew xxvii, 60). In place of the pater beads are seven brass plaques, representing each, on one side, Mary with seven swords piercing her heart ; on the other, the incidents in Christ's life enumerated above. The cross is formed of beads. Length, 33 inches. (Plate 29, fig. 4. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

89. *Catholic rosary*.—The lesser Dominican rosary of five decades of small blue glass beads, while the five pater beads are of the seeds of the *Abrus precatorius* (called "crabs' eyes," or "jumble beads"). Inclosed in an egg-shaped box of bone. Length, 12 inches. Diameters of the box, 1 inch by three-fourths of an inch. Madrid, Spain. (Plate 29, fig. 5. Cat. No. 167020, U.S.N.M.) Collected by Dr. Walter Hough.

90. *Catholic rosary*.—The lesser Dominican rosary of small black glass beads. Instead of the cross are two oval brass plaques bearing the image of Mary. Length, 22 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

91. *Catholic rosary*.—The lesser Dominican rosary of small green glass beads. In place of the cross is an oval brass plaque bearing the image of the Virgin of Guadalupe of Mexico. The paters are marked by double beads of the same size and color as the aves. Length, 26 inches. Mexico. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

92. *Catholic rosary*.—The lesser Dominican rosary of wooden beads, painted black. Worn at the girdle by members of the Fraternity of the Misericordia (Arciconfraternita de Santa Maria della Misericordia) in Italy. Length, 50 inches. Pisa, Italy. (Cat. No. 153893, U.S.N.M.) Collected by Dr. G. Brown Goode.

93. *Catholic rosary*.—The Franciscan rosary of seven decades of beads made of composition. This rosary is used for the devotion in honor of the seven mysteries in the life of Mary, namely, the conception (Luke i, 26) ; the visitation (Luke i, 39) ; the nativity (Luke ii) ; the adoration of the magi (Matthew ii) ; the presentation (Luke ii, 21) ; the finding in the temple (Luke ii, 41), and the apparition after the resurrection to Mary. The rosary is provided with two rings for suspending from the girdle. Length, 6 feet 8 inches. (Plate 30, fig. 1. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

94. *Catholic rosary*.—The lesser Dominican rosary of black glass beads. An oval bronze medal,  $1\frac{3}{4}$  and  $1\frac{1}{2}$  inches in diameter, which takes the place of the cross, has on one side the bust of St. Ignatius



Loyola (1491-1556), the founder of the Society of Jesus, on the other the figure of St. John of Nepomuk, the patron saint of Bohemia, who, according to tradition, was martyred in 1383. The rosary is provided with two rings to be suspended from the girdle. Probably worn by Jesuits. Length, 55 inches. Plate 30, fig. 2. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

95. *Catholic rosary*.—Used in the devotion of the crown of our Lord. Consists of 33 beads made of wood for the paters, to commemorate the years of Christ's life on earth, and five for the aves, in honor of the five wounds. The cross is substituted by a brass medal, 1½ inches in diameter, engraved with the instruments of the passion and the latin words, "The passion of Christ save us, the passion of Christ comfort me." Between the ave beads is inserted a piece of bone, 1½ inches high, carved with the faces of Christ and Mary, and that of a skull. Length, 47 inches. (Plate 30, fig. 3. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

96. *Catholic rosary*.—Consisting of three sets of nine beads each, made of composition, separated by an oval brass plaque, having on one side a representation of the Trinity, on the other the gloria in Latin. Length, 21 inches. (Plate 30, fig. 4. Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

97. *Catholic rosary*.—The Franciscan chaplet of seven decades of beads made of composition. (See under No. 93.) The cross of wood is inlaid with mother-of-pearl. Length, 42½ inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

98. *Catholic rosary*.—The Franciscan chaplet of seven decades of small purple-colored glass beads. (See under No. 93.) Length, 33 inches. Philippine Islands. (Cat. No. 205535, U.S.N.M.) Collected by Mr. J. A. Gies.

99. *Catholic rosary*.—Consisting of 51 beads made of composition, strung on a cord, with crosses, medals, and figurines at irregular intervals. Length, 18 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

100. *Catholic rosary*.—Consisting of 33 beads made of olive wood. Used in the devotion of the crown of our Lord. (See under No. 95.) Length, 44 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

101. *Catholic rosary*.—Consisting of 33 small blue glass beads. Used in the devotion of the crown of our Lord. (See under No. 95.) Length, 19 inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.

102. *Catholic rosary*.—Consisting of 26 beads of Job's tears and composition alternating. Length, 13½ inches. (Cat. No. 179075, U.S.N.M.) Collected by Dr. G. Brown Goode.



103. *Catholic rosary*.—Consisting of eight decades of small pink-colored glass beads. Length, 36 inches. Philippine Islands. (Cat. No. 205536, U.S.N.M.) Collected by Mr. J. A. Gies.

104. *Catholic rosary*.—Consisting of thirteen decades of beads made of black wood, without the introductory beads. Used by the Tagalogs of Luzon, P. I. Length, 34 inches. Luzon, P. I. (Cat. No. 216990, U.S.N.M.) Collected by Mr. Frank F. Hilder.

105. *Catholic rosary*.—Consisting of nine decades of beads made of black wood. Used by the Tagalogs of Luzon, P. I. Length, 33 inches. Luzon, P. I. (Cat. No. 216990, U.S.N.M.) Collected by Mr. Frank F. Hilder.





TIBETAN ROSARY OF SHELL BEADS.

FOR REFERENCE TO PLATE SEE PAGE 337.



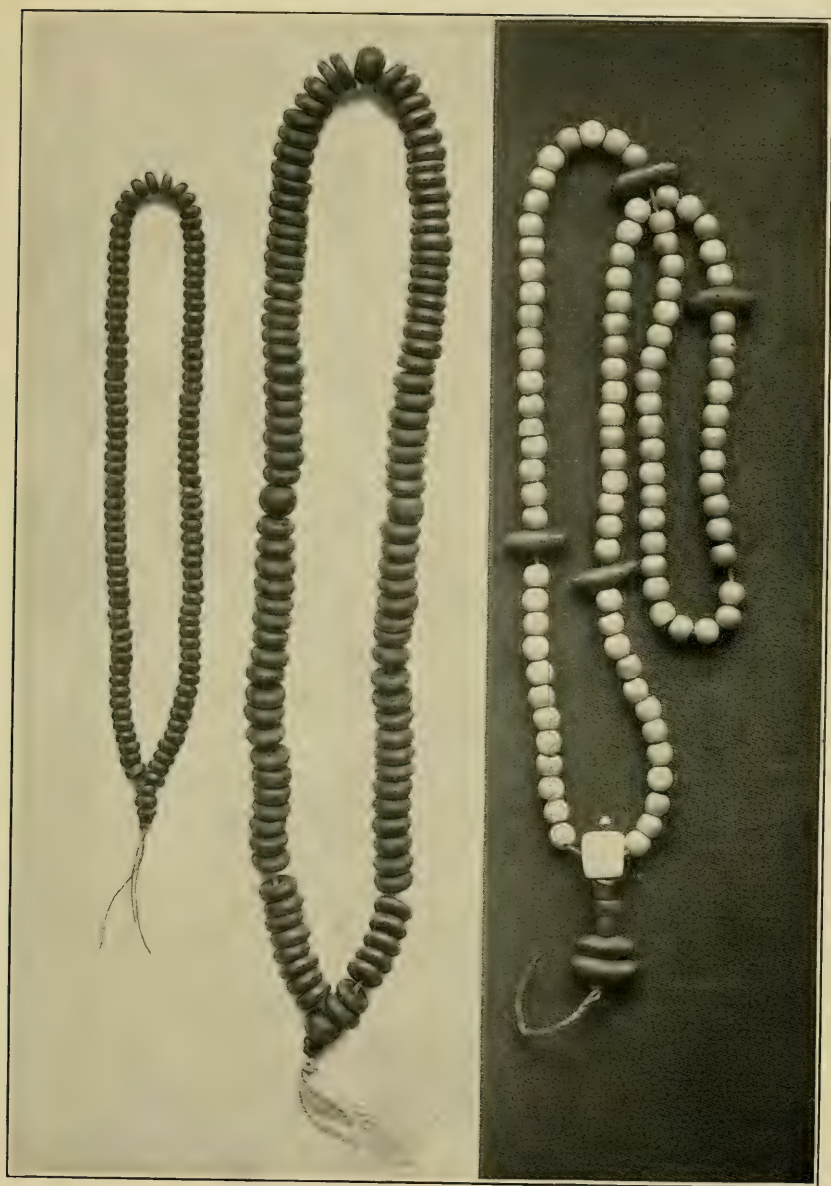




EXPLANATION OF PLATE 22.



- Fig. 1. ROSEWOOD ROSARY. TA-CHIEN-LU.  
2. YELLOWWOOD ROSARY. BATANG.  
3. MOHAMMEDAN ROSARY, OF BONE AND DATE SEEDS. HSI-NING-FU.

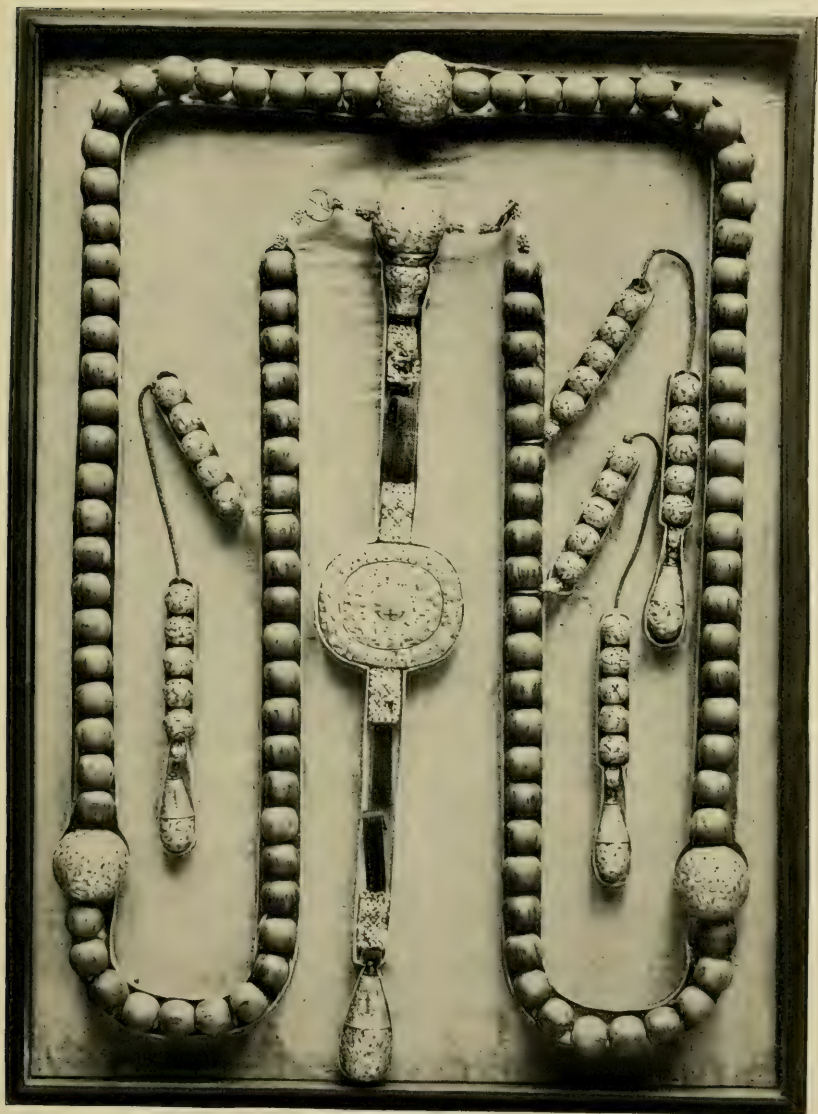


TIBETAN AND MOHAMMEDAN ROSARIES.

FOR REFERENCE TO PLATE SEE PAGES 338, 350.







CHINESE OFFICIAL SU-CHU.

FOR REFERENCE TO PLATE SEE PAGE 339.





CHINESE OFFICIAL SU-CHU.

FOR REFERENCE TO PLATE SEE PAGE 339.







EXPLANATION OF PLATE 25.

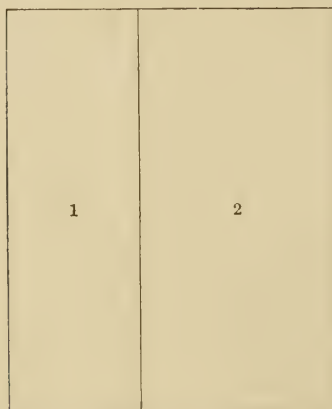


Fig. 1. ROSARY OF MOTHER OF PEARL. JAPAN.  
2. SHINTO ROSARY, OF GLASS PIECES. JAPAN.



JAPANESE ROSARIES.

FOR REFERENCES TO PLATE SEE PAGES 343, 344.



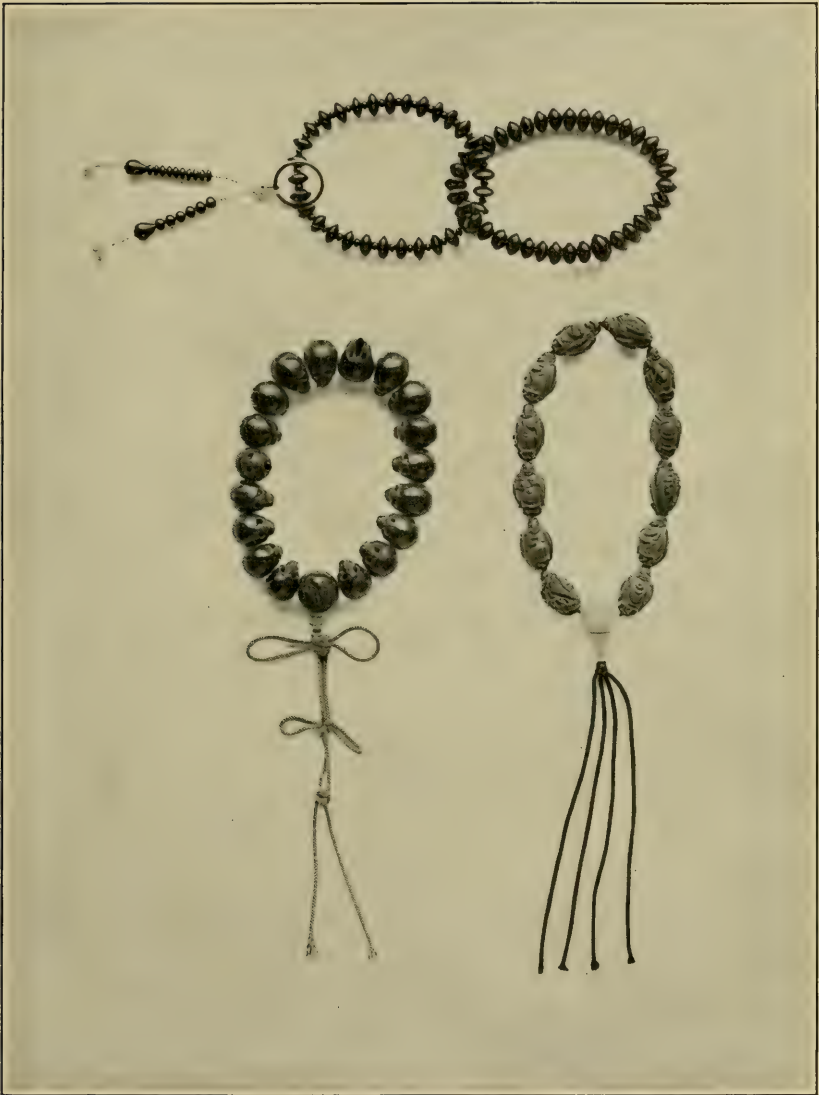




EXPLANATION OF PLATE 26.



- Fig. 1. DOUBLE ROSARY OF THE JODO SECT, OF MAHOGANY. JAPAN.  
2. ROSARY OF SKULL-SHAPED BEADS, OF WALNUT SHELLS. JAPAN.  
3. ROSARY WITH BEADS CARVED TO REPRESENT ROHANS. JAPAN.



JAPANESE ROSARIES.

FOR REFERENCES TO PLATE SEE PAGES 345, 346.



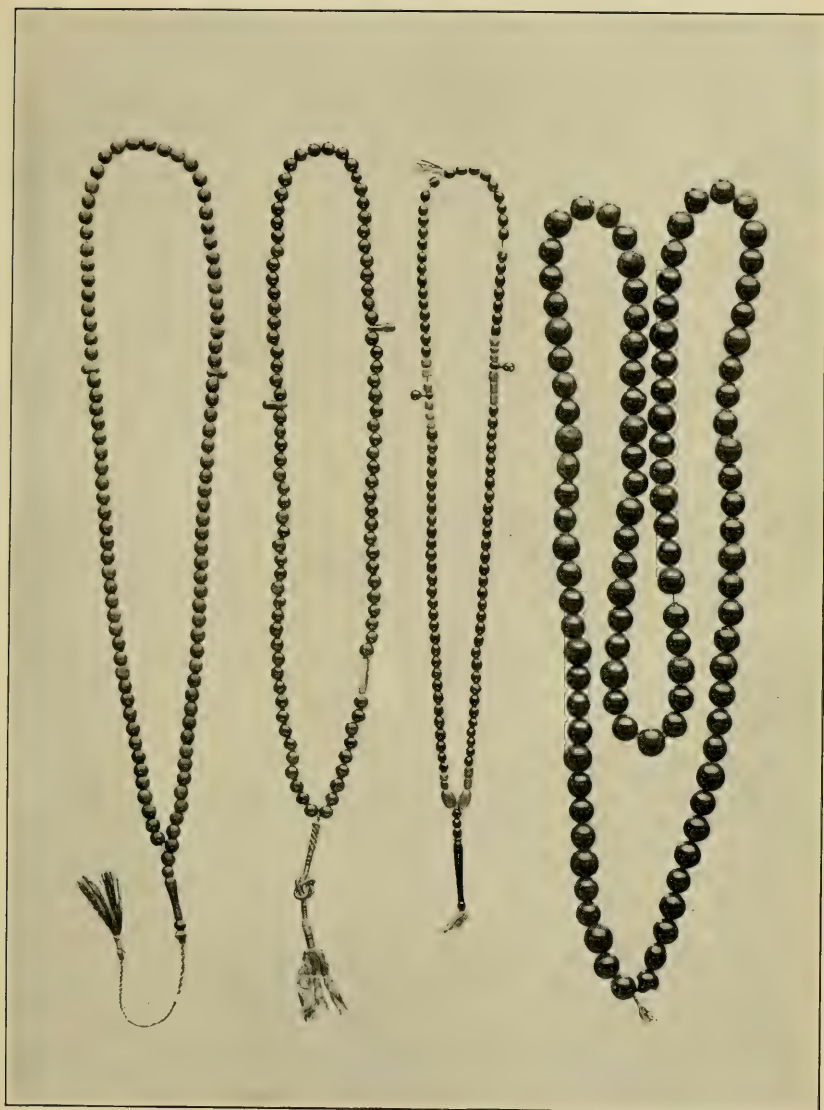




EXPLANATION OF PLATE 27.

1	2	3	4
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- Fig. 1. MOHAMMEDAN ROSARY, OF OLIVE WOOD. CAIRO, EGYPT.  
2. MOHAMMEDAN ROSARY, OF BLOODSTONES.  
3. MOHAMMEDAN ROSARY, OF HORN.  
4. MOHAMMEDAN ROSARY, OF COMPOSITION. MOUNT SINAI, SYRIA.



MOHAMMEDAN ROSARIES.

FOR REFERENCES TO PLATE SEE PAGES 349, 350.







EXPLANATION. OF PLATE 28.



Fig. 1. CATHOLIC ROSARY, OF EBONY.  
2. CATHOLIC ROSARY, OF MAHOGANY.



ROMAN CATHOLIC ROSARIES.

FOR REFERENCE TO PLATE SEE PAGE 355.



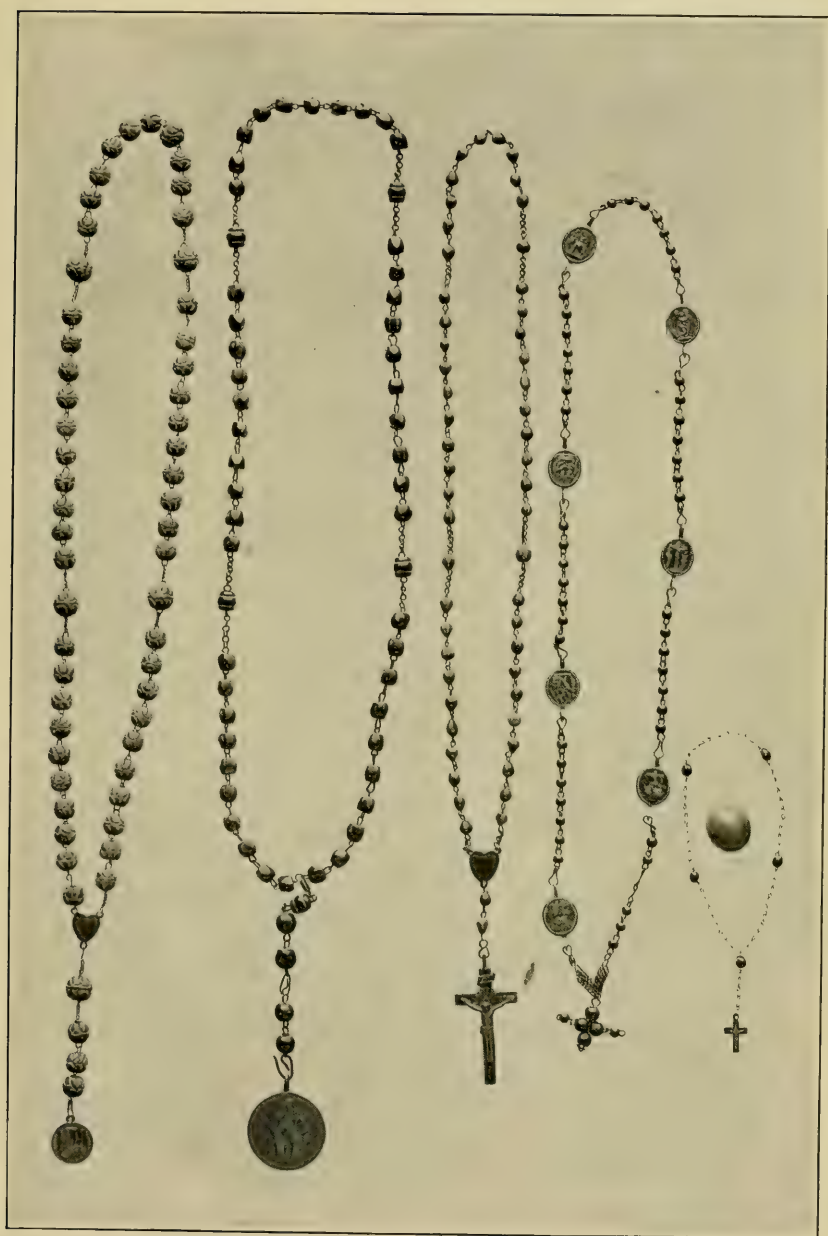




# EXPLANATION OF PLATE 29.



- Fig. 1. CATHOLIC ROSARY, OF OLIVE WOOD. ROME, ITALY.  
 2. CATHOLIC ROSARY, OF IVORY.  
 3. CATHOLIC ROSARY, OF JOB'S TEARS.  
 4. CATHOLIC ROSARY, OF COMPOSITION.  
 5. CATHOLIC ROSARY, OF GLASS AND SEEDS OF ABRUS PRECATORIUS, WITH EGG-SHAPED BOX. MADRID.



ROMAN CATHOLIC ROSARIES.

FOR REFERENCES TO PLATE SEE PAGES 356, 357.







EXPLANATION OF PLATE 30.



- Fig. 1. CATHOLIC ROSARY, OF COMPOSITION, WITH TWO RINGS.  
2. CATHOLIC ROSARY, OF BLACK GLASS BEADS, WITH TWO RINGS.  
3. CATHOLIC ROSARY, OF WOOD, WITH CARVED PIECE OF BONE.  
4. CATHOLIC ROSARY, OF COMPOSITION.



ROMAN CATHOLIC ROSARIES.

FOR REFERENCES TO PLATE SEE PAGES 357, 358.





## COMATILIA, A REMARKABLE NEW GENUS OF UN-STALKED CRINOIDS.

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By AUSTIN HOBART CLARK,

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The elaborate definition of the genus *Actinometra* (the family Comasteridæ as now understood) given by Dr. P. H. Carpenter in the Challenger Reports, and the various additional characters noted by him in different places in the same work, would seem to have established its status definitely, and to have demonstrated conclusively that it formed a well-circumscribed unit, very sharply contrasted with the aggregation of species called by Doctor Carpenter *Antedon*; in other words, that the recent free crinoids without basals and with ten or more arms fall naturally into two well-defined structural types, separated from each other by more numerous and more important characters than exist between the various specific groups within the two types. At the beginning of my studies I had become convinced from the available material that the division of these forms into two sharply contrasted groups was very artificial, and could not stand the test of modern systematic methods, in the light of our greatly increased knowledge. I therefore proposed to recognize, instead of the two genera "*Antedon*" and "*Actinometra*" used by Carpenter, five great divisions (the families Comasteridæ, Zygometridæ, Himerometridæ, Tropiometridæ, and Thalassometridæ) which covered exactly the same ground, except that the number of included species was nearly, if not quite, doubled. Each of these families appeared to me to be separated from the others by characters of just as great importance as the Comasteridæ (the old *Actinometra*) was from any one of them.

My suspicions in regard to many of the characters relied upon to differentiate "*Actinometra*" from "*Antedon*" have recently been confirmed in a most conclusive manner. In examining some comatulids taken by the U. S. Bureau of Fisheries steamer *Albatross* in deep water between the Bahama Islands and Cape Fear, North Carolina, I found a most peculiar form which, according to the structure of its oral pinnules and brachials, belongs to the Comasteridæ, but

which, judged upon its other characters, might be placed in the Antedonidæ, Himerometridæ, Thalassometridæ, or Tropiometridæ, while certain features find a parallel only in *Rhizocrinus* and *Bathycrinus*. Briefly stated, the essential features of the Comasteridæ are, an eccentric mouth, large central or subcentral anal tube, ambulacra quite without calcareous plating, absence of sacculi, stout cirri with short joints, and the full complement of pinnules, the lowest of which bear terminal combs. The first and the last are the characters upon which most reliance is usually placed. In this new form the mouth is always central, the anal tube small and marginal, sacculi are present (though rare), the cirri are exceedingly slender, with greatly elongated joints, the six pinnules following the first two ( $P_1$  and  $P_a$ ) are lacking, the pinnule ambulacra are provided with large side plates, and the two lowest pinnules are combed. In its central mouth this new species agrees with all the other recent species except those of the Comasteridæ, and the same is true in regard to the sacculi; the delicate cirri find counterparts only in the Antedonidæ, in the genera *Hathrometra* and *Iridometra*; the deficient pinnulation recalls *Perometra* and *Hypalometra* among the Antedonidæ, *Cyllometra* and *Colobometra* among the Himerometridæ (with this exception, that the first inner pinnule, on the fourth brachial,  $P_a$ , is always the first to disappear in these genera, while it is invariably present in the new form), and also *Atelecrinus* of the Atelecrinidæ; the development of an ambulacral plating is found perfected only in the Thalassometridæ and in the Tropiometridæ. Taken as a whole, the greatest resemblance in size and general build is to the little littoral Antedonids of the East Indies belonging to the genus *Iridometra*, *I. nana* in particular, and this in spite of the fact that it has the deepest habitat of any of the Comasteridæ.

The development of plating along the ambulacra in the family Comasteridæ was first demonstrated by Mr. Frank Springer, who showed its presence in a new species of *Comaster*, *C. iowensis*, from the Tortugas. I have since found it to be a constant feature of the West Indian species of this genus, even including *C. lineata*, in which I detected it in specimens previously examined by Carpenter.

No less interesting than the adults are the young, as shown by a single specimen with an arm length of probably about 7 mm. Had it not been found with the fully grown, it could very well have passed as a new species of *Thaumatocrinus*, or the representative of a genus intermediate between *Thaumatocrinus* and *Antedon*.

*Thaumatocrinus renovatus* was based upon a very peculiar comatulid which had been dredged by the *Challenger* in  $50^{\circ} 01'$  S. lat.,  $128^{\circ} 04'$  E. long., at a depth of 1,800 fathoms. Doctor Carpenter's diagnosis of the genus, as given in the Challenger Reports, is:

Calyx composed of a centro-dorsal, basals, radials, and primary interradials, the latter resting on the basals and so separating them

laterally; that on the anal side bears a short jointed appendage; mouth central and protected by five large oral plates which occupy the greater part of the disk, and are separated from the calyx interradials by two or three rows of small irregular plates; five arms only.

Doctor Carpenter discusses at considerable length the similarity between *Thaumatocrinus* and a number of palaeozoic forms, and, although he includes it in the "Comatulidæ" as understood by him, he is inclined to regard it as a very anomalous type, exhibiting certain atavistic characters. The type-specimen of *Thaumatocrinus renovatus* is exceedingly small; the total width of the calyx across the disk is barely 2 mm., and the height of the centro-dorsal and radials together is about the same.

The arm structure of *Thaumatocrinus* is identical with that of *Pentametrocrinus* and *Decametrocrinus*, which together form the family Pentametrocrinidæ, and in its pinnule and cirrus structure, in so far as it can be made out, it also agrees with the conditions found in those genera. The arm and pinnule structure of the Pentametrocrinidæ is unique in its simplicity among the comatulids, which in itself suggests that it is a family of a remarkably primitive type. The adult *Pentametrocrinus* differs from the adult *Antedon* in its more generalized and presumably more primitive structure; if we take a young *Antedon* and generalize it by supplementing its single interrarial (anal) with four others like it, we would find a *Thaumatocrinus* as a result. *Thaumatocrinus* in every detail except such as, from analogy with *Antedon*, may be safely ascribed to immaturity, agrees with *Pentametrocrinus*; hence it seems probable, as the atavistic *Thaumatocrinus* bears a very similar relation to the young *Antedon* to that which the primitive *Pentametrocrinus* does to the adult *Antedon*, and as *Thaumatocrinus* and *Pentametrocrinus* agree in all essentials fully as well as the young and the adult of *Antedon* agree, that *Thaumatocrinus* is in reality nothing more nor less than the young of *Pentametrocrinus*. But there is still further evidence. In *Decametrocrinus*, which is a meristic variation from *Pentametrocrinus*, differing only in having twice as many radials and arms, the ends of the five basal rays appear externally in the angles of the calyx, dividing the ten radials into groups of two; but in *Promachocrinus*, which is a similar meristic variation from *Heliometra* or a closely allied genus, the ends of the basal rays appear externally under the center of alternate radials. *Promachocrinus* probably has young much like those of the closely allied *Heliometra*, in which there is but a single interrarial plate, the anal; now the division of each radial in the young of *Promachocrinus*, and the growth of each resultant half to the same size as the single undivided radial in *Heliometra*, would, as the anal plate is lifted out from between the posterior radials, produce a certain amount of torsion of the



calyx, and might very well result in causing the basals in the adult to occupy a position under alternate radials. The appearance of the basal rays in *Decametrocrinus* between the radials instead of under alternate ones is a difference of considerable morphological importance, suggesting that the young are of quite different structure. *Decametrocrinus* is a meristic variation from *Pentametrocrinus*; *Thaumatocrinus*, probably the young of *Pentametrocrinus*, has interrarial plates of equal size in all the interrarial areas; now if the young of *Decametrocrinus* were of the *Thaumatocrinus* type with five equal interradians which, during growth, were shoved out from between the radials at an equal rate, the basal rays in the adult would maintain exactly the same relation to the radials as the basals did to the radials in the young, instead of being twisted about into a semiradial position as in *Promachocrinus*. Thus a comparison of adults of the ten-rayed genera of the Pentametrocrinidae and Antedonidae leads to the same conclusions as a comparison of *Thaumatocrinus* with the *Antedon* larva, namely, that *Thaumatocrinus* is the young of *Pentametrocrinus*.

By this reasoning I had sometime ago reached the conclusion that *Thaumatocrinus* was very close to *Pentametrocrinus*, and probably the young of it, and I therefore placed it next to *Pentametrocrinus* in the family Pentametrocrinidae. Here the matter rested, for nothing further could be done without additional facts to prove or disprove the results attained by purely speculative processes.

The young example of this new comatulid is so like *Thaumatocrinus* in certain ways as to convince me that I was right in my tentative treatment of that genus. It represents, however, a more advanced stage; the five large, strong orals are present as in *T. renovatus*, surrounded by small irregular plates; the basals are not evident externally; the radials are in lateral contact, and just above their apposed lateral edges in the angles of the calyx are five large interradians which appear to have been recently thrust forward from between them, but which are not yet undergoing the process of resorption. In the large and persistent orals and interradians (though displaced) this young specimen resembles *Thaumatocrinus*, though it is true that it differs from it in the approximation of the radials and in the absence of external basals; but there can, I think, be no reasonable doubt that these differences are merely the result of its greater development. The arm structure, so far as it is elaborated, resembles that of the adult.

This new form is undoubtedly referable to the Comasteridae, as evidenced by the characteristic pinnules with short joints, coarsely spinous on their distal ends, finely spinous dorsally, the comb on the terminal portion of the first pair, the coarsely spinous overlap of the brachials, and their spinous dorsal surface. This appears to out-



weigh all the other features. The ambulacral plating is unlike that developed in the Antedonidæ, Tropiometridæ, or Thalassometridæ, in that there is only a single series of plates instead of both side and covering plates; these appear to represent the side plates of other forms, and not the covering plates, as does the single series in *Rhizocrinus*. The development of covering plates is an uncertain quantity, and one upon which too much stress has previously been laid. Hartlaub and Minckert both divided the old genus "*Antedon*" into two sections, one with and one without them; but both included in the "plated" section Carpenter's "Basicurva group," which contains species in which they are not found. Moreover, in the Tropiometridæ they are extraordinarily developed in *Calometra*, more or less imperfectly developed in *Asterometra* and *Ptilometra*, and quite undeveloped in *Tropiometra*; but more curious still, while they make their appearance in the pentacrinoid stage of the species of Thalassometridæ, they are not found in the young of *Ptilometra*. It is evident, therefore, that, though a valuable index to the systematic position of the comatulid species, they must be treated with great caution, as they appear to be very liable to sudden development, as is the case in *Heliometra*, in very unexpected places, and to equally disconcerting suppression. The central position of the mouth, while interesting, is of no real importance; it is usually nearly, and often quite, central, in *Phanogenia*, *Comatella*, and *Comaster*, and often more or less eccentric in *Heliometra* and in certain of the Himerometridæ. Sacculi are somewhat uncertain organs at best, while cirri are so very variable that the occurrence of a new type need cause no trouble; the resemblance to the cirri of *Iridometra* is not borne out by the finer structure; for instance, in *Iridometra*, as in all comatulids heretofore known, the opposing spine is single, whereas in this new form it is forked.

I propose to recognize this new comatulid as follows:

**Genus COMATILIA, new.**

Centro-dorsal discoidal, moderate in size; cirrus sockets marginal, usually in a single row.

Cirri about XX, 9–10, about one-fifth of the arm length, very slender, the second and following joints much longer than broad, the third and fourth the longest, about four times as long as their proximal diameter; cirrus joints all with expanded ends; no dorsal spines; opposing spine forked in its distal half, or ending in a bunch of fine spines.

Arms 10; first four brachials oblong, broader than long, then obliquely wedge-shaped, at first as long as broad, soon becoming longer than broad and very long terminally; large interprimibrachs present, rounded, not contiguous.

Disk naked; mouth central, very large; anal tube small, marginal.

PP <sub>23, 33, 43, b, c, d</sub> absent; PP <sub>1</sub> and <sub>2</sub> long and slender, with a large terminal comb; pinnules from PP <sub>5, e</sub> gradually increasing in length, distally reaching approximately the length of the oral pinnules; the first three to six after PP <sub>5, e</sub> bear globular genital glands at the base; side plates developed on the outer three-fourths of the pinnule ambulacra, best developed in the distal half.

*Genotype*.—*Comatilia iridometriformis*.

COMATILIA IRIDOMETRIFORMIS, new species.

Centro-dorsal moderate, discoidal, the bare polar area flat, usually with a more or less developed low rounded median tubercle, 1 mm. to 1.5 mm. in diameter; cirrus sockets usually in a single, but often in a more or less partially double or triple marginal row.

Cirri XVI–XXVIII, 9–10, 5 mm. to 6 mm. long, exceedingly slender and delicate; first joint short, about twice as broad as long; second about twice as long as broad; third and fourth the longest, about four times as long as broad; fifth slightly shorter; following joints gradually decreasing in length, the antepenultimate being about half again as long as its distal diameter; penultimate joint about as long as, or slightly longer than, broad; second and following joints strongly “dice-box shaped” with expanded ends; after the fourth the proximal ends becoming less, the distal more expanded, so that the cirri as a whole bear a close resemblance to those of certain of the Antedonidæ, as *Hathrometra* and *Iridometra*; distal ends of the cirrus joints overlapping all around, but slightly more dorsally than ventrally, the dorsal overlap, however, exhibiting no tendency to project anteriorly; opposing spine terminal in position, directed obliquely forward, arising from the entire distal half (or rather more) of the dorsal side of the penultimate joint, about equal to one-half of the distal diameter of the joint in length, usually forking transversely in its distal half, more rarely breaking up into a number of small spines; terminal claw approximately equal in length to the penultimate joint, moderately stout, and evenly curved.

Ends of the basal rays visible as rather prominent tubercles in the interradial angles of the calyx; radials very short in the median line, but extending up in the angles of the calyx, separating the bases of the IBr<sub>1</sub> for a distance about equal to one-half of the basal diameter of those joints, the condition in general resembling that found in *Calometra multicolor* and in *Bathymetra*; two to four large oval or round interprimibrachs are found in each interradial area, which, however, are usually not quite contiguous; IBr<sub>1</sub> comparatively small, oblong, very short, between three and four times as broad as long; IBr<sub>2</sub> (axillary) broadly pentagonal, about twice as broad as long, the lateral edges about as long as those of the IBr<sub>1</sub>, making with them an obtuse angle.

Arms 10, about 30 mm. long; first brachial very short, oblong, about four times as broad as long, united basally with its fellow, diverging at approximately a right angle distally; second brachial usually about twice as large, wedge-shaped; third and fourth brachials (syzygial pair) somewhat longer than broad; following brachials very obliquely wedge-shaped, at first about as long as broad, but almost immediately becoming longer than broad and gradually increasing in length, being terminally two or three times as long as broad, or even longer, with expanded ends; after about the sixth the brachials develop strongly produced and overlapping distal ends, which are armed with a row of comparatively coarse spines. Syzygies occur between the third and fourth brachials, again between the thirteenth and fourteenth, and distally at intervals of two oblique muscular articulations ("in alternate joints").

Mouth central and very large; anal tube small and marginal; disk naked, except for the previously mentioned interprimibrachial plates.

No pinnules on the fifth to the tenth brachials,  $PP_{2, 3, 4, 5, 6, 7, 8, 9}$  being absent;  $P_1$  4 mm. to 4.5 mm. long, with twenty joints, slender, and tapering evenly distally; first joint not so long as broad, second and third about as long as broad, the remainder about half again as long as broad; the joints are somewhat constricted centrally and have expanded and overlapping distal ends which are armed with fine spines, and a finely spinous dorsal surface; terminal comb very prominent, composed of six to eight large teeth, trapezoidal or blunt triangular, their bases in contact, somewhat higher than the transverse diameter of the joint which bears them, and recurved;  $P_a$  similar to  $P_1$ ;  $P_5$  (the next pinnule) 3 mm. long with twelve joints, the first two not so long as broad, the third about as long as its proximal diameter, the remainder somewhat longer than broad; all but the first have greatly expanded distal ends, armed with comparatively coarse spines; a very round and prominent genital gland is found on the second-fourth or second-fifth joints; following pinnules slowly increasing in length, the joints, except the two first, slowly becoming more and more elongated; distal pinnules about 4.5 mm. long, or about the length of the oral pinnules; the genital glands are found on three to six pinnules on either side of the arm and are always small and situated basally, like that on the first genital pinnule; large side plates are developed along the sides of the pinnule ambulacra of the third and following joints, becoming more perfect distally.

*Color* (in spirits).—Brownish white, the perisome yellow brown; probably yellow in life.

*Type*.—Cat. No. 25460, U.S.N.M., from Albatross Station No. 2670; between the Bahama Islands and Cape Fear, North Carolina; 280 fathoms.





## DESCRIPTION OF A NEW SPECIES OF LEATHERBACK TURTLE FROM THE MIOCENE OF MARYLAND.

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By WILLIAM PALMER,  
*Of the U. S. National Museum.*

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During July, 1908, while Mr. D. B. Mackie and myself were searching for fossils along the Calvert Cliffs, in Calvert County, Maryland, we discovered some hard, stony plates of a peculiar nature, which puzzled us for some time. The first piece found was in a lump of wet, sandy clay at the line of high water. It stood on edge, and could only be examined, without disintegrating, on its under surface. After considerable examination and discussion, we decided that it was either a piece of crude Indian pottery or a piece of baked clay, possibly the bottom of an oven or burning place. Attention was then attracted to a larger mass of drier clay near by, which, after a few minutes of picking and cleaning, developed a similar back and edge exposure, and also an upper surface divided into many small, interlocking, flat plates, the whole being 562 mm. long and 130 mm. wide, and composed of about 100 plates. Greater interest in the find being thus excited, much of the débris was examined, with the result that many separate plates were found, and also a few pieces in which several or many were still united. An examination of the face of the cliff was then made, disclosing not only the place from whence the material had recently fallen, but also, some 30 feet above the beach, a clearly-defined section of what was evidently an inverted shell or carapace about 4 feet (1,220 mm.) across. The ends were turned upward for about 8 inches (204 mm.), and a very distinct and heavy ridge projected downward from its center. A number of steps were cut into the cliff and efforts made to get near the remains, but the treacherous nature of the wet clay and the fact that the shell was located in an overhanging portion of the cliff compelled us to abandon the attempt for a time. On another visit several days later, with tools and ropes, we were unfor-

tunate enough to find that the remaining part of the shell and much of the cliff had fallen, and were mixed in fragments with the earlier débris. It became necessary, therefore, to carefully dig over all the talus material, and to wash much of it also, in order to extract the plates, which were generally separated. In this way many hundreds were recovered, together with a few broken and badly disintegrated vertebrae, ribs, and other bones, one piece only being in fair condition.

A superficial examination of this material, which required several days' labor to bring away, led to the conclusion that the remains probably belonged to a mammal resembling a *Glyptodon*, but later, on comparing the plates and the best of the bones with the skeletons of several turtles, it became clear that they represented an animal closely related to the living Leatherback Turtle, though differing in several respects.

Dermal scutes of this same species had been previously picked up from the beach bordering the cliffs by Dr. F. W. True, and later by myself, but their true nature, though often commented on, was not satisfactorily determined until the remains herein described were found.

**PSEPHOPHORUS CALVERTENSIS, new species.**

*Dermatochelys*, J. MÜLLER, Ueber die fossilen Reste der Zeuglodonten von Nord-Amerika, 1849, p. 34, pl. 27, fig. 7. Upper Eocene Zeuglodon beds of Alabama. A fragment, evidently of the plastron, comprising 13 scutes and parts of scutes.

*Type-specimen*.—Cat. No. 6059, U.S.N.M. (Catalogue of Fossil Vertebrates). A few bones and numerous scutes of the carapace and plastron, many joined together, collected in July, 1908, 2 miles south of Chesapeake Beach, in the Calvert Cliffs, Calvert County, Maryland, by William Palmer and David B. Mackie. From the top of the lower stratum of a Middle Miocene cliff.

Carapace composed of numerous, thick, bony scutes, mostly large; slightly, or not at all, sculptured on the dorsal surface, and generally longer than broad. One strong and prominent median, straight, longitudinal ridge, and several, perhaps six, minor parallel ridges, or thickenings of the scutes. Minor ridges but slightly raised above the adjoining scutes and seemingly decreasing in height according to their distance from the more pronounced median ridge. Scutes of the ridges about twice as long as wide, the ridge-slopes covering the whole surface of the scutes and extending over adjoining ones; not confined to the central portion of the ridge-scutes as in *P. polygonus* and *D. coriacea*. Transverse sutures generally narrower than the longitudinal sutures, and sometimes anchylosed. Plates usually very close-fitting below, almost or quite anchylosed. Under surface quite uneven, having somewhat the appearance of wet clay which has been

touched by the fingers: usually with a small pit near the center. Scutes of the outer and posterior edges much smaller and thinner than the others, and very similar to those of *D. coriacea*. Scutes of the plastron quite thick and smooth, with well-rounded outlines; those of the edge forming an undulating line. (Plate 31, fig. *F*.)

Among the best-preserved bones there is the upper half of a vertebra which is nearly perfect. It differs from a similar vertebra in *D. coriacea* principally in the size of the articular surface for the ribs, which is very much larger than in that species. Several pieces of ribs are also very similar, but one piece (fig. *A*), perhaps a tip, has very fine striations on its curved side and is smooth and reddish brown in color. The bones are light and very porous, and, consequently, many of the more prominent surfaces are badly disintegrated, a condition evidently due to the seepage of water through the stratum in which they were embedded.

On comparing our specimens with the excellent plate of the type-material of *P. polygonus* in Professor Seeley's paper,<sup>a</sup> and with a cleaned specimen of the carapace of *D. coriacea* in the National Museum, the differences in the ridges and shapes of the scutes were very evident. The scutes of the anterior median portion of the carapace are distinctly different in the three species, but as the outer and posterior edges are reached the scutes of the three species become quite similar. The large, thick scutes composing the anterior portion of the median ridge in *P. calvertensis* differ decidedly from similarly placed scutes in the other species. In our specimen, the ordinary scutes are flat above or nearly so, and their edges are not raised, so that the surface of any two adjoining scutes is continuous. In the lateral ridges, the rows of raised scutes are but slightly thickened and rounded along the middle (fig. *D*), and there is a tendency toward a parallel arrangement of adjoining scutes. Many of the separate scutes, as well as the larger pieces, are much waterworn and otherwise injured. It is possible that the surface was more distinctly sculptured originally, and that the sculpturing has been eroded.

Professor Seeley writes<sup>b</sup> that Von Meyer (1851) pointed out the striking resemblance of the carapace of *P. polygonus* to one from the zeuglodont limestone of North America which Müller had figured and compared with the dorsal shield of *Dermatochelys* [= *Dermochelys*] in his work on *Zeuglodon*. On comparing our material with Müller's excellent figure, it seems evident to me that his specimen was a part of a plastron, agreeing closely with ours in the size, shape, and general appearance of the scutes. The dominant, or more characteristic, scutes of these three species differ from each other decid-

<sup>a</sup> Quart. Journ. Geol. Soc., London, 36, 1880, p. 406, pl. 15.

<sup>b</sup> Idem, p. 407.



edly in size and shape and other particulars, but the differences are those of degree only, and as far as our present knowledge extends, the species may all be considered as belonging to the same genus.

During our many trips along the Calvert Cliffs, we found between tides several pieces of bones evidently belonging to turtles. They were all heavy and black. One piece appeared to be the central portion (about half) of a scapula, and on comparison with a scapula of *D. coriacea* would seem to belong to *P. calvertensis*. It differed from the same part in *D. coriacea* in being slenderer and flatter. The piece,  $6\frac{1}{2}$  inches (165 mm.) long, appears to indicate that the scapula is shorter than that of *D. coriacea*.

The following is a list of species which have been referred to *Psephophorus*:

**PSEPHOPHORUS POLYGONUS** Von Meyer.

- Psephophorus polygonus* VON MEYER, N. Jahrbuch, 1846, p. 472, and 1847, p. 579; Ber. Mit. Freund. Naturw., 1851, p. 3.—VON HAUER, Verh. k.-k. geol. Reichsanst., 1868, p. 387, and 1870, p. 342; FUCHS, Verh. k.-k. geol. Reichsanst., 1874, p. 220.—SEELEY, Quart. Journ. Geol. Soc. London, 36, 1880, p. 406, pl. 15.—WOODWARD, Proc. Geol. Ass. London, 11, 1889, p. 13.  
*P[sephophorus] polygonus*, DOLLO, Ann. Soc. Sci. Bruxelles, 11, 1887, p. 139; Bull. Mus. Roy. Hist. Nat. Belg., 5, No. 1, 1888, p. 83.

The type-species, known only from a few bones and many scutes, from near Neudörfl, Austria, in Pliocene sandstone. Specimen, including the type material, now in the museum of the Imperial Geological Survey, Vienna. The slab of hard sandstone in which the remains are preserved is 460 mm. by 410 mm. wide.

**PSEPHOPHORUS PESUDOSTRACION** (Gervais).

- Sphargis pseudostracion* GERVAIS, Dict. Univ. Hist. Nat. (Ch. d'Orbigny), 11, 1848, p. 56; Zool. et Pal. Franç., 2d ed., 1859, p. 438, pl. 9, fig. 1.  
*P[sephophorus] (Sphargis) pseudostracion*, DOLLO, Bull. Mus. Roy. Hist. Nat. Belg., 5, No. 1, 1888, p. 83.

Type-locality, Vendargues, near Montpellier (Hérault), France. Miocene. First considered to be a fish, *Ostracion* sp.

**PSEPHOPHORUS RUPELIENSIS** (Van Beneden).

- Sphargis rupeliensis* VAN BENEDEN, Bull. Acad. Roy. Belg., 3d ser., 6, (1883), p. 665.—WOODWARD, Proc. Geol. Ass. London, 11, 1889, p. 13.  
*P[sephophorus] (Sphargis) rupeliensis* DOLLO, Bull. Roy. Hist. Nat. Belg., 5, No. 1, 1888, p. 83.

Type-locality, Boom, Belgium. Middle Oligocene.

**PSEPHOPHORUS SCALDII** (Van Beneden).

- Macrochelys scaldii* VAN BENEDEN, Bull. Acad. Roy. Belg., 2d ser., 31, 1871, p. 13.—DOLLO, Bull. Mus. Roy. Hist. Nat. Belg., 5, No. 1, 1888, p. 75.  
*P[sephophorus] (Macrochelys) scaldii*, DOLLO, Bull. Mus. Roy. Hist. Nat. Belg., 5, No. 1, 1888, p. 83.

Type-locality, Antwerp, Belgium. Pliocene and Miocene.



PSEPHOPHORUS sp., Lydekker.

*Psephophorus* sp., LYDEKKER, Cat. Foss. Rept. Brit. Mus., 1889, Pt. 3, p. 224.  
Sussex, England. Middle Eocene.

PSEPHOPHORUS EOCÆNUS Andrews.

*Psephophorus eocænus* ANDREWS, Geol. Mag., 4th ser., 8, 1901, p. 440, fig. 3;  
Desc. Cat. Tert. Vert. Fayûm, Egypt, 1906, p. 275.

Type-locality, Qasr-el-Sagha beds, Egypt. Middle Eocene.

EXPLANATION OF PLATE 31.

*Psephophorus calvertensis*.

- A. Portion of a rib, probably the tip, showing striations.
- B. Under side of a scute.
- C, C. Under side of scutes, showing the central pit.
- D. A minor lateral ridge, 9 mm. thick.
- E. Portion of the medium ridge, 200 mm. long; center, 20 mm. thick; edge, 12 mm. thick.
- F. Edge piece of the plastron, 135 mm. long; 10-14 mm. thick.
- G. Piece of a median ridge, 155 mm. long; center, 21 mm. thick; edges, 8-11 mm. thick. Lateral view.





A NEW SPECIES OF LEATHER-BACK TURTLE.

FOR EXPLANATION OF PLATE SEE PAGE 377.





## FOUR NEW SPECIES OF ISOPODS FROM THE COAST OF CALIFORNIA.

By S. J. HOLMES and M. E. GAY,  
*Of the University of Wisconsin, Madison.*

The specimens of the new species here described were collected on the coast of California by Dr. S. J. Holmes and sent to the U. S. National Museum.

### ANCINUS GRANULATUS, new species.

Body very broad and much depressed, contractile, evenly and densely granulated. Thorax with parallel sides. Head twice as broad as long; front produced into a rectangular lobe between the bases of the antennules; a small lobe on the anterior margin on either side of the median one. Eyes small and round.

Antennæ nearly equal in length; the flagellum of the first somewhat longer than the peduncle and composed of about 10 joints. Second antennæ with the flagellum about 10-jointed and longer than the peduncle; both furnished with setæ having a brush of radiating hairs at the tip.

Mandibles with the palp situated behind the middle, the last two joints furnished on the distal part of the outer margin with setose spines, those of the last joint increasing in length toward the tip. Palp of the maxillipeds with the first joint very short, the second and third joints as wide as long and produced into a rounded setose lobe on the inner margin; fourth joint produced at the distal end of the inner margin into a rounded setose lobe; last joint oblong, distally rounded and setose, and about three-fourths the length of the preceding one.

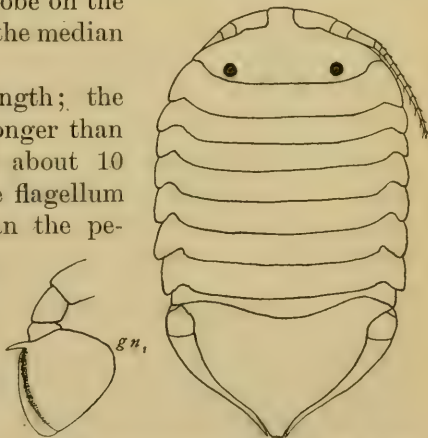


FIG. 1.—ANCINUS GRANULATUS; *gn*<sub>1</sub>, FIRST GNATHOPOD.

First pair of legs with a broad hand having a very convex anterior margin; palm comprising nearly all the posterior margin of the hand, evenly curved, and furnished with a long spine at the upper end. The following legs increasing in length posteriorly and furnished on the margins with long spines and fine cilia.

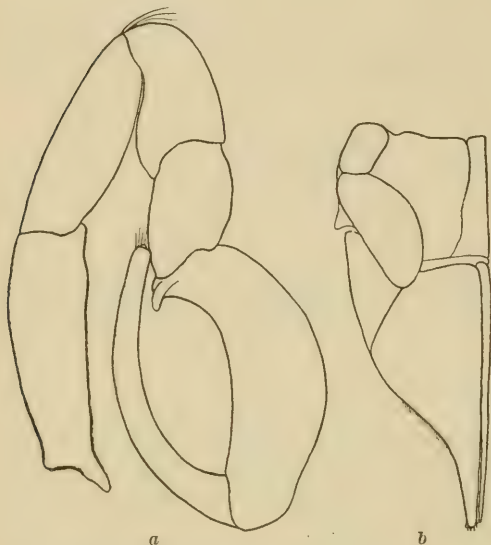


FIG 2.—*ANCINUS GRANULATUS*; *a*, SECOND LEG; *b*, SECOND PLEPOD OF THE MALE. THESE FIGURES, WHICH WERE KINDLY SUPPLIED BY MISS H. RICHARDSON, ARE DRAWN TO A LARGER SCALE THAN THE PRECEDING ONES.

This is the only species of the genus known to occur on the Pacific coast. It is broader and flatter than *Ancinus depressus* Say of the coast of New Jersey and has a more broadly triangular terminal segment of the abdomen.

**TYLOS PUNCTATUS, new species.**

Oblong, covered with scattered short spines or acute granulations. Eyes nearly round. First antennæ single jointed, scale like. Second antennæ less than one-fifth the length of the body, not reaching the middle of the first thoracic segment: a hook-like process on the second joint of the peduncle; third joint nearly as long as the two preceding; flagellum slightly longer than the last joint of the peduncle, the third joint nearly as long as the two preceding; fourth joint short, conical, and furnished with numerous setæ at its distal end. Lateral lobes of the head with two triangular projections in front of the eyes.

First abdominal segment very short. Terminal segment triangular with slightly sinuous margins, the tip narrowly rounded when seen from above, but having a deep notch on the lower side. Uropods with a single movable, styliform ramus, which nearly or quite reaches the tip of the abdomen.

*Length*, 8 mm.

*Locality*.—Near Coronado Island, California, from a depth of 3 fathoms.

*Type*.—Cat. No. 39046, U.S.N.M.

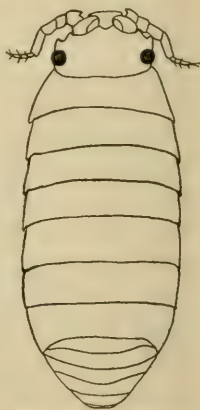


FIG. 3.—*TYLOS PUNCTATUS*.

Thoracic segments subequal, the epimera in all produced backward and rounded at the posterior angle. Legs very spiny, the terminal part of the claw marked off by an apparent suture from the longer basal portion; first pair of legs with an acute lobe near the distal end of the anterior margin of the second joint; fourth joint produced and rounded in front.

Third abdominal segment and to a less extent the fourth produced backward at the outer posterior angle; lateral process of fifth segment small. Last segment truncated and four or five times as broad as long. Uropods nearly semicircular in outline, armed with a few scattered spines, the small terminal joint furnished with a few spines and several setae.

*Length*, 10 mm.

*Locality*.—San Diego, California, in sand near the beach.

*Type*.—Cat. No. 39047, U.S.N.M.

No other representative of the family Tyliidae is known from the west coast of North America.

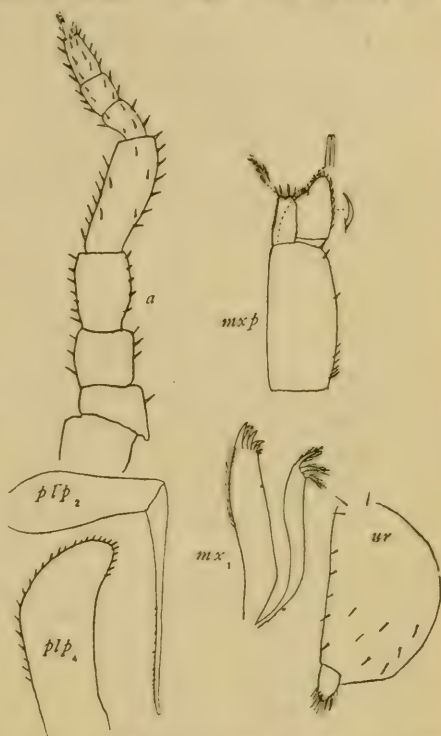


FIG. 4.—*TYLOS PUNCTATUS*; *a*, ANTENNA; *mx*<sub>1</sub>, FIRST MAXILLA; *mxp*, MAXILLIPED; *plp*<sub>2</sub>, SECOND PLEOPOD OF THE MALE; *plp*<sub>4</sub>, FOURTH PLEOPOD; *ur*, UROPOD.

*ACTONISCUS TUBERCULATUS*, new species.

Body elliptical in outline and furnished with small tubercles. Head deeply inserted, with an acute median lobe and prominent rounded lateral ones. Eyes oval. Antennae not one-third the length of the body, the second joint of the peduncle a little longer than the third and about twice the length of the first; fourth joint longer than the third but not quite so long as the fifth; flagellum with four evident joints and a minute terminal fifth joint. The peduncle is bent between the second and third, and the fourth and fifth joints.

Maxillipeds with a rounded setose inner lobe; palp short and broad, the first joint much wider than long, the second triangular with slightly lobulated inner margin, the tip with a brush of long setae.

Legs similar, spiny, a long ciliated spine on the lower margin of the fifth joint.

Basal joint of uropods large, similar to the coxal plates of the preceding segments, and setose on the distal margin; rami extending about to the tip of the peduncle, the outer one inserted at the middle of the inner margin of the basal plate, the inner one near the base; both tipped with setæ.

*Length*, 3.25 mm.

*Locality*.—San Diego, California, on moist ground near the seashore.

*Type*.—Cat. No. 39048, U.S.N.M.

This species seems to be closely allied to *Actoniscus ellipticus* Harger from the Atlantic coast. The body is somewhat broader and the lateral processes of the segments are more nearly rectangular in outline, especially in the abdomen, and more prominent.

**PHILOSCIA RICHARDSONÆ**, new species.

FIG. 5.—*ACTONISCUS TUBERCULATUS*.

Body oblong-oval, covered with short minute spinules. Head twice as wide as long; frontal margin arched; lateral angles subacute. First thoracic segment longer than the following ones, the last three segments produced backwards at the lateral angles. Antennæ about one-half as long as the body, the last joint of the peduncle about as long as the third and fourth; flagellum triarticulate, nearly as long as the fifth joint of the peduncle, the first and third joints subequal and a little longer than the second; last joint ending in a spine.

Legs similar, increasing gradually in length from before backwards, and very spiny.

Abdomen abruptly much narrower than the thorax, the lateral angles of the third, fourth, and fifth segments produced backwards; last segment over twice as broad as long, with the posterior margin concave on either side of the narrowly rounded tip. Basal joint of

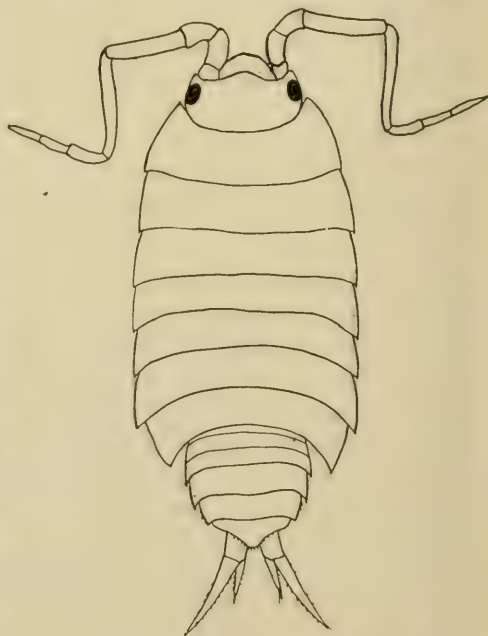


FIG. 6.—*PHILOSCIA RICHARDSONÆ*.



the uropods about as broad as long; outer ramus slender, acuminate, subconical, with the outer margin nearly straight and the inner one somewhat convex; inner ramus about one-third the length of the outer, subconical, with narrow blunt tip which is armed with one or more sharp spines; scattered short spines occur on both rami.

*Length*, 5 mm.

*Locality*.—San Diego, California, on moist swampy ground.

*Type*.—Cat. No. 39049, U.S.N.M.

Named after Miss Harriet Richardson, who has contributed so much to our knowledge of the North American Isopoda.



## NOTES ON TWO SLUGS OF THE GENUS VERONICELLA.

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By W. W. ROBBINS and T. D. A. COCKERELL,  
*Of Boulder, Colorado.*

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Slugs of the genus *Veronicella* are numerous in the tropical regions of both hemispheres, 154 species having been described up to the present time. Dr. D. F. Heynemann <sup>a</sup> has given a map of the world, showing the distribution of the known species. In this map Australia is shown to be without *Veronicella*, with the exception of a couple of species found at Brisbane; and these latter, according to Henry Tryon, <sup>b</sup> have almost certainly been introduced. Nothing is known of *Veronicella* in New Guinea, where the related but very distinct genus *Prisma* takes its place. The group to which the names *Atopos*, *Prisma*, and *Padangia* have been applied extends from north Queensland through New Guinea to Amboina, Celebes, the southern Philippines, Sumatra, the Malay Peninsula, and Cochin China. Westward it occupies the same general regions as *Veronicella*, but eastward it seems to occur to the exclusion of it. Leaving the Austro-Malay region and passing on to the islands of the Pacific, we again meet with species of *Veronicella*, in New Caledonia, the Loyalty Islands, the New Hebrides, and even as far as the Fijis and Tahiti. The species of the Pacific Islands, noticeable for their rather small size, have been described from rather inadequate material, with the exception of *V. willeyi* Collinge <sup>c</sup> from Lifu, Loyalty Islands. Further details have been especially desired in the hope of throwing some light on the origin of these animals. They are more or less arboreal, and the presumption would be that they were originally carried to the islands on floating trees; but the available ocean currents appear to set wholly from the American side, implying South American origin and a voyage of extraordinary length. It does not appear possible at the present time to demonstrate any close affinity with either the South American or Asiatic groups of *Veronicella*; but when we know more about the

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<sup>a</sup> Die Geographische Verbreitung der Nachtschnecken, 1905, pl. 2.

<sup>b</sup> Queensland Agricultural Journal; July, 1899, p. 5.

<sup>c</sup> Willey's Zoological Results, Pt. 4, 1899.

anatomy of the various neotropical and Malayan species this may be done. On the whole, in spite of the currents, it seems likely that the Pacific species are of Asiatic origin; and perhaps it may be assumed that in past times the currents of the Pacific Ocean were very different from what they are to-day. This is especially suggested by the fact that whereas the North Equatorial current, passing the Hawaiian Islands, comes from the American coast, the Hawaiian fauna shows every indication of having arrived from the opposite direction.<sup>a</sup>

Pilsbry<sup>b</sup> draws attention to the antiquity and comparative homogeneity of the mid-Pacific snail-fauna, and considers that the former (late palæozoic or early mesozoic) existence of a mid-Pacific continent is strongly indicated. This may be true, but it hardly seems possible to account for the *Veronicellæ* as remnants of the ancient fauna; and we are thus left to assume the agency of ocean currents, unless it can be believed that man carried these slugs about during his early migrations.

VERONICELLA AGASSIZI Cockerell.

This species was described<sup>c</sup> from a specimen obtained by Dr. Alexander Agassiz in Tipaerui Valley, Tahiti. It was not possible to determine the anatomical characters, and nothing was known of the variation. Mr. R. W. Doane, of Stanford University, when recently in Tahiti, kindly collected a considerable series of specimens, which have made it possible to put the species on a much sounder basis. The original description of the external features remains valid; the specimens received are very uniform in appearance, the younger ones being paler than the adults. The dorsal surface is granular with small warts; its color coffee-brown, marbled with black, with no distinct dorsal band. Some of the younger specimens show slight indications of a dorsal band, consisting merely of a stripe on which the mottling is absent, and along the margins of which it tends to accumulate.<sup>d</sup> The general form of the animal is shown in figs. 2 and 5. *V. gilsoni* Collinge,<sup>e</sup> from the Fiji Islands, appears to be the nearest ally. So far as the external measurements go, there is no substantial difference. The color of *V. gilsoni* appears to be distinctive, and at present can not be matched in any of the Tahitian material. The

<sup>a</sup> An ancient element of the Hawaiian flora, including several endemic genera of Compositæ, appears to be of American origin; while an apparently more recent group is Polynesian (Wallace, *Island Life*, 2d ed., pp. 325-6). The Tahitian Compositæ show Malayan affinities.

<sup>b</sup> Proc. Acad. Nat. Sci. Phila., 1900, pp. 568-581.

<sup>c</sup> Proc. U. S. Nat. Mus., XXIII, p. 835.

<sup>d</sup> The same sort of thing, more exaggerated, is seen in the South American *Veronicella fusca* Heynemann.

<sup>e</sup> Journ. of Malacology, VII, p. 179.



anatomy of *V. gilsoni* is unknown. The following table of Pacific *Veronicellæ* will assist in the separation of the species:

Dorsum with a very distinct light yellow band; female orifice close to sole; accessory glands 12 to 20.....	<i>V. willeyi</i> Collinge.
Dorsum without a band, or with at most traces of one, not lighter than the ground color.....	1.
1. Ground color dirty yellow, with small blackish blotches....	<i>V. gilsoni</i> Collinge.
Ground color dark coffee brown.....	2.
2. Form very broad, the breadth about half the length (according to the figure)	<i>V. brunnea</i> Collinge.

(Evidently based on a juvenile.)

Form narrower, the breadth less than half the length; accessory glands 8  
*V. agassizi* Cockerell.

Our largest *V. agassizi* is 36 mm. long and 14 mm. broad, the sole 3.5 mm. broad and the female orifice 3 mm. from sole and 23 mm. from anterior end. The average measurements were: Length, 25.6 mm.; breadth, 11.6; breadth of sole, 2.7; female orifice from sole, 2.1; female orifice from margin, 2.8, and from anterior end, 14.8. The female orifice is distant from the head 56.4 per cent of the total length.

The jaw is normal, strongly ribbed, as is sufficiently shown in fig. 1. The teeth are normal for the genus, with blunt dark points. The median tooth is small and narrow, the cusp not projecting beyond the basal plate. The first laterals are large and simple in form (fig. 4). The marginal teeth, as usual, are much smaller than the laterals.

The male generative organs are normal for the genus. The accessory glands are strikingly different from those of *V. willeyi*, being much shorter (little more than half the length of the dart-sac) and fewer in number (eight in the specimen examined). In *V. willeyi* they are not only numerous, but conspicuously longer than the dart-sac. The intestine is formed essentially as in *V. willeyi* and *V. brunnea*, but the stomach is covered by the liver. (See fig. 3.)

#### VERONICELLA SCHIVELYÆ BAHAMENSIS Dall.

This form was described by Doctor Dall<sup>a</sup> from Nassau and Little Abaco, Bahamas. The typical *V. schivelyæ* Pilsbry comes from Bermuda and is exceedingly similar to the Mexican *V. moreleti* Crosse and Fischer. Upon comparing the descriptions of *V. moreleti* and *schivelyæ* (external characters), nothing distinctive was found, except that the female orifice was slightly more posterior in *schivelyæ*, and the dorsal bands were rather nearer to each other than either to the edge of the body. In the *bahamensis* form the bands are more or less evanescent in the adult though well-marked in the young. In all a strongly distinctive feature is the projection of the foot beyond the body posteriorly.

<sup>a</sup> Smithsonian Misc. Coll., XLVII, p. 446.

As the anatomy of the *schivelyæ* forms was unknown, we were anxious to dissect specimens. Doctor Dall has very kindly sent us a specimen of *bahamensis* collected in the Bahamas by Mr. Riley. It is only half the size of the types, and unusually pale in color. Unfortunately, the generative organs were not developed, but fig. 8 represents the under surface, showing the projecting foot, and fig. 7 one of the alimentary canal and liver.

On the whole, it seems not unlikely that the Bahama and Bermuda slugs have been introduced from Mexico, and are in fact *V. moreleti*. This can not be demonstrated, however, until much more material is obtained, both of the Mexican and insular forms. The species of Florida, Cuba, and Jamaica, so far as known, are not of the *moreleti* type.

The measurements of the specimen of *V. schivelyæ bahamensis* examined by us are as follows: Length, 38 mm.; breadth, 16; breadth of sole, 5; female orifice from the sole, 2.5; from margin, 3.5; from anterior end, 21. The female orifice is distant from the head 55 per cent of the total length.

#### EXPLANATION OF PLATE 32.

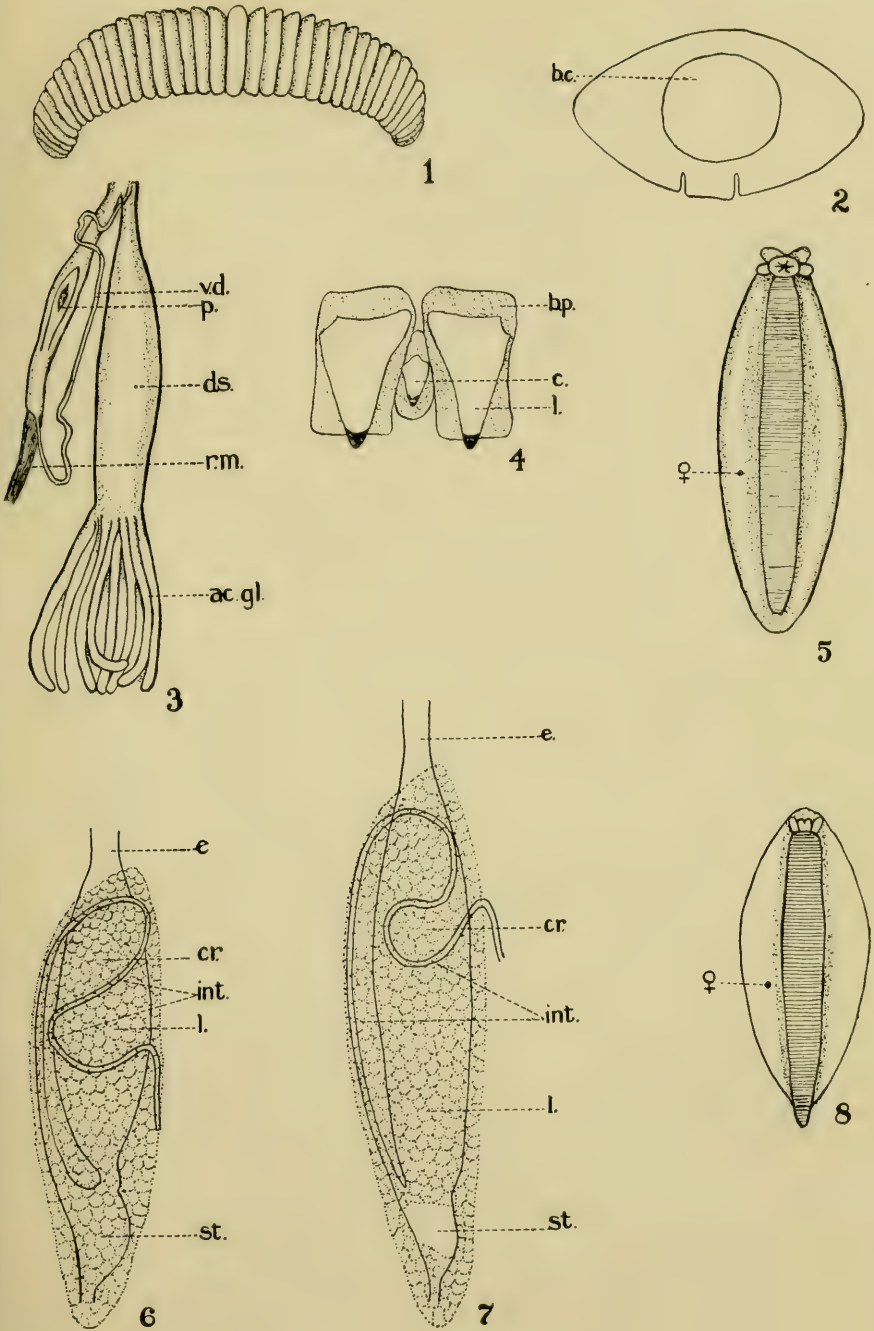
*Veronicella agassizi* Cockerell.

FIG. 1. Jaw.

2. Diagrammatic transverse section through the body. *b. c.*, body cavity.
3. Male generative organs. *ac. gl.*, accessory glands. *d. s.*, dart-sac. *p.*, penis. *r. m.*, retractor muscle, *v. d.*, vas deferens.
4. Teeth. *b. p.*, basal plate. *c.*, central tooth. *l.*, lateral.
5. View from ventral side.  $\times 2$ . Female generative orifice.
6. Alimentary canal and liver. *cr.*, crop. *e.*, esophagus. *int.*, intestine. *l.*, liver. *st.*, stomach.

*Veronicella schivelyæ bahamensis* Dall.

7. Alimentary canal and liver. Lettering as in fig. 6.
8. View from ventral side. Natural size. ♀ Female generative orifice.



TWO SLUGS OF THE GENUS VERONICELLA.

FOR EXPLANATION OF PLATE SEE PAGE 388.





## ANYAM GILA (MAD WEAVE): A MALAYSIAN TYPE OF BASKET WORK.

By OTIS T. MASON, .

*Late Head Curator, Department of Anthropology, U. S. National Museum.*

In the W. L. Abbott collections of basketry from southwestern Malaysia, in the U. S. National Museum, are a number of specimens made in a variety of technic not known in America.

It was first made public by Mrs. L. E. Bland, of the Penang Residency, Straits Settlements, in the *Journal of the Straits Branch, Royal Asiatic Society*, No. 46. Mrs. Bland studied the art among the Malay women of Tanjong Kling, Malacca, and also mentioned the same ware from the province of Wellesley, from Siamese territory, from elsewhere on the peninsula, as well as from Sumatra and other islands.

The baskets are made from narrow strips of pandanus, or screw pine, leaves, of which there are many species. In the specimens described by Mrs. Bland the "mengkuang" (*Pandanus fascicularis*) was used.

The material is prepared by the old women, who cut the long, prickly leaves with a woman's parang, or native knife,<sup>a</sup> and carry them home in large bundles on their heads. They next dry, or "layor," the leaves over a fire of sticks and cut off the thorns that grow down the spine. This divides the leaf into two wide strips, for which purpose a smaller knife, called "pisau," is used.<sup>b</sup>

The women then divide the half leaves into uniform strips by means of a rude gauge, or "jangka."<sup>c</sup> This is a flat piece of wood with brass spikes fixed into one end at regular intervals, governed by the width of the required strips, varying from  $\frac{1}{8}$  inch to 1 inch. At the same time the thorny edges are removed.

The strips are next made supple and smooth, or "lurut," with a "pulurut," a piece of hollow bamboo pulled over the leaf many times

<sup>a</sup> See *Journ. Roy. Asiatic Soc., Straits Branch*, pl. 4, fig. *a*; and pl. 15, *Proc. U. S. Nat. Mus.*, XXXV.

<sup>b</sup> *Idem*, pl. 4, fig. *b*

<sup>c</sup> *Idem*, pl. 4, fig. *c*.

by the left hand with a curling movement.<sup>a</sup> The smooth strips are folded into compact bundles and soaked in cold water for three nights, changing the water twice a day. After this they are bleached in the sun for a day and are then ready for use.

Mrs. Bland's account of the preparation of the materials is most helpful, and, before giving a detailed description of the drawings and processes shown, an abstract of her description will throw much light on the native practice.

The basket starts from six strands crossed in the middle of the bottom and the fabric is built up by working in three directions, braiding, not weaving. The strands go from left to right in the process. After the work reaches the rim of the basket, the strips are turned back over a rattan split and inwoven, as will be fully explained.

The strips of pandanus are glossy on one side only. In this they resemble the split roots and cane of the Pacific coast Indians and of the tribes of the Gulf States. In order to have the basket smooth on both sides, the native women work their splits and strips in pairs.

But the "mad weave" maker proceeds on an entirely different plan. After the basket has been wrought from bottom to rim in single ply, the strips are inwoven backward to the center of the bottom by tucking under, the glossy side being outward and the ends of strips being cut off invisibly.

On the way back pretty designs are frequently made by curling and folding the strips between thumb and forefinger. Mrs. Bland speaks of these as "rice grains" and they are worked into stars or hexagons, which are further bunched into single or combined geometric patterns.<sup>b</sup>

The "mad weave" is worked up into various shapes, but the hexagon is the prevailing form. All of them—square, oblong rectangular, oval, and diamond shape—start with the six-sided motive and are brought by skill into other designs.

In 1906 Henry Balfour, esq., of Pitt-Rivers Museum, Oxford, England, took up the "mad weave" and reproduced it in tapes of three colors. He described the system as an under-two-and-over-one ( $\frac{2}{1}$ ) and an under-one-and-over-two ( $\frac{1}{2}$ ) system of interweaving. The difficulty comes from having three sets of parallel strands.

In 1907 I was so fortunate as to secure the cooperation of some arts and crafts friends, with the result that Miss Edwina H. Fallis, of Denver, Colorado, through Mrs. Wright Jones produced a one-ply specimen, and Mrs. Mary Wright Gill, of Washington City, worked out the mad weave detail now to be described and illustrated.

<sup>a</sup> Straits Branch Journal, No. 46, pl. 4, fig. d.

<sup>b</sup> Idem, pl. 6.

The technic is from pandanus strips of various widths, in close twill, in three directions, to be spoken of as vertical, dextral, and sinistral; the terms right oblique and left oblique may replace the last two. When the work is finished the surface is made up of rhombs or diamond-shape checks, giving the appearance of cubes and six-pointed stars. As before mentioned, the fabric is twice wrought, or two ply, so as to have both the inside and the outside of the basket expose the glossy side of the leaf.

The technic here detailed is based on Cat. Nos. 219963 and 236282 in the U. S. National Museum. The former is in the W. L. Abbott collection from Rumpin River, Pahang, and the latter is from Malacca, sent to the Museum by Mrs. L. E. Bland.

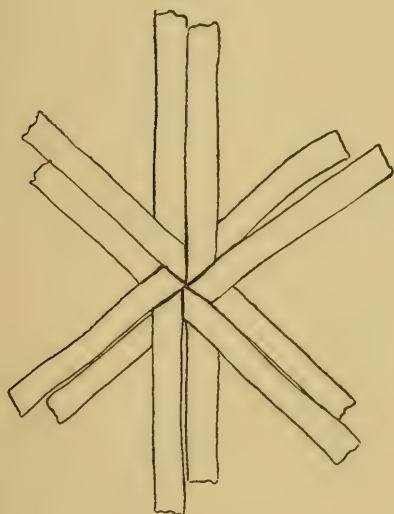


FIG. 1.—METHOD OF BEGINNING MAD WEAVE.

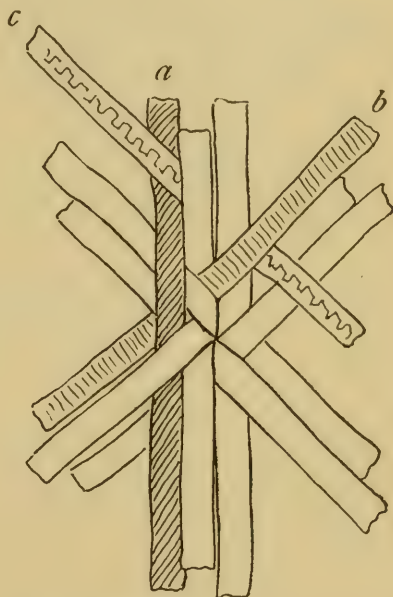


FIG. 2.—METHOD OF ADDING ADDITIONAL STRIPS.

Fig. 1 shows how the work is started from the center of the bottom, with six prepared strips, two sinistral, two vertical, and two dextral, crossing at the middle, one of each pair passing over and under one strip in each of the other pairs. This is the foundation.

Fig. 2, *a-c*, illustrates how strips are next added. A vertical strip (*a*) passes down over two sinistrals, under one dextral and over one dextral. The dextral strip (*b*) passes upward over one sinistral, under one sinistral, and over two verticals. The sinistral strip (*c*) passes upward over two dextrals, under two verticals and over one vertical.

Fig. 3, *a-i*, shows the result of adding more strips in the three directions and fig. 4, looking from the inside of the basket is fig. 3

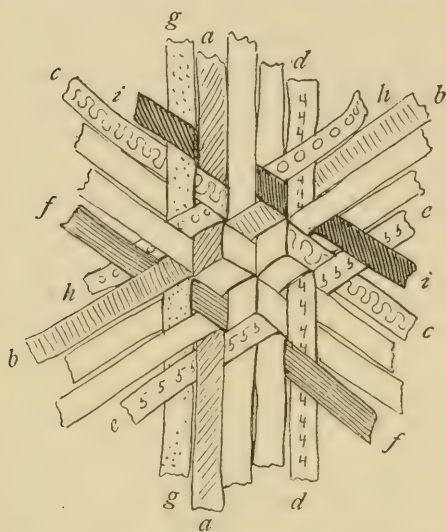


FIG. 3.—RESULT OF ADDING NEW STRIPS IN THREE DIRECTIONS.

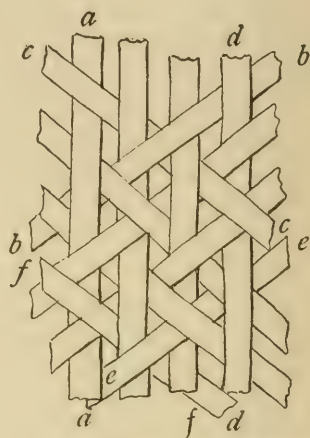


FIG. 4.—FIGURE 3 DISSECTED (INSIDE).

dissected. The sinistral strips are uniformly under two and over one vertical and over two and under one dextral (figs. 5*a* and 5*b*).

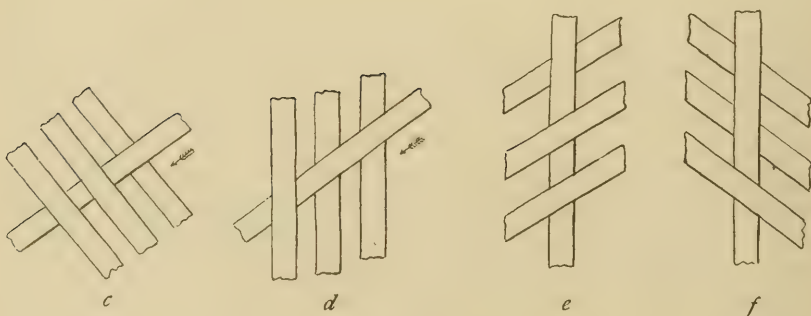
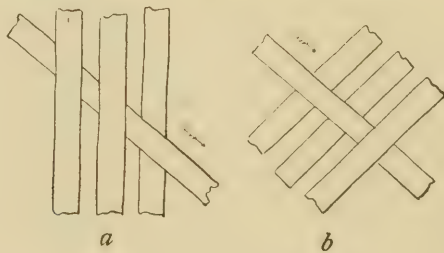


FIG. 5 *a*, POSITION OF SINISTRAL STRIP; *b*, POSITION OF SINISTRAL STRIP; *c*, POSITION OF DEXTRAL STRIP; *d*, POSITION OF DEXTRAL STRIP; *e*, POSITION OF VERTICAL STRIP; *f*, POSITION OF VERTICAL STRIP.



The dextral strips are uniformly over one and under two sinistral and over two and under one vertical (figs. 5*c* and 5*d*). The vertical strips are uniformly over one and under two dextral and over two and under one sinistral (figs. 5*e* and 5*f*).

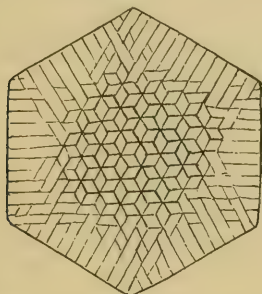


FIG. 6.—METHOD OF GIVING HEXAGONAL FORM TO BASE, AT UPSET.

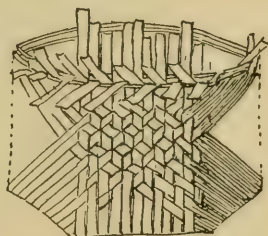


FIG. 7.—METHOD OF FINISHING AT THE BORDER, WITH TWO HOOPS OF RATTAN.

In fig. 6 is shown a continuation of the bottom in single technic, with the rough side of the strips outward, indicating the method of giving the hexagonal form to the base at the upset. Fig. 7 illus-

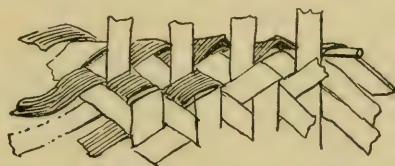


FIG. 8.—METHOD OF TURNING STRIPS AT THE BORDER, POLISHED SIDE OUT.

trates the interweaving of strips to form sides and the turning at the border over two hoops of rattan. At the lower end of these hoops the dextral and sinistral strips cross (fig. 8) and are inwoven

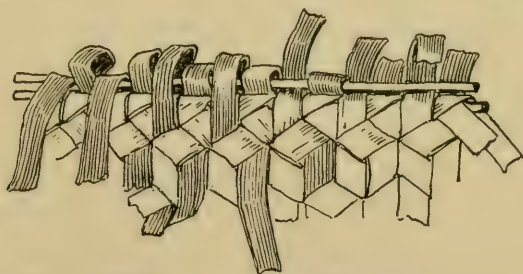


FIG. 9.—METHOD OF TURNING VERTICAL STRIPS AT THE BORDER, POLISHED SIDE OUT.

back with the polished side out, over the whole surface of the basket and are cut off where they meet, usually at one side of the bottom, or at the upper edge of the design, if there be one.

The vertical strips are carried over the upper hoop—the alternate ones moving from outside and from inside—and are inwoven

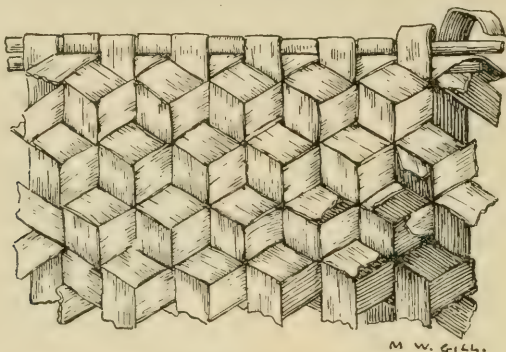


FIG. 10.—METHOD OF FINISHING AT THE BORDER.

back over the rough surface, leaving the polished side out (figs. 9 and 10).

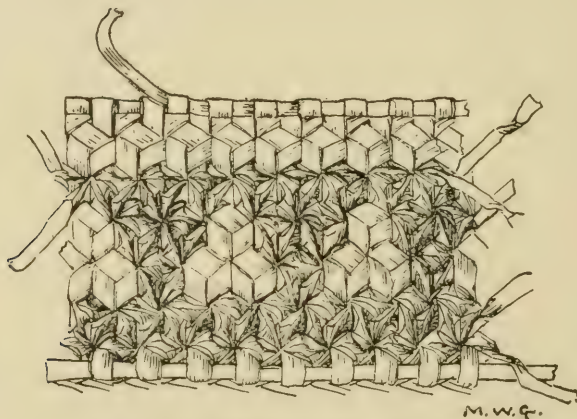


FIG. 11.—METHOD OF ORNAMENTATION.

The ornamental designs, which are not common in the Abbott collections, are formed, as mentioned, by curling or twisting the outer layer of strips as they are inwoven (fig. 11).

## ON A COLLECTION OF RECENT CRINOIDS FROM THE PHILIPPINE ISLANDS.

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By AUSTIN HOBART CLARK,

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The second consignment of crinoids received from the United States Fisheries steamer *Albatross*, now working among the Philippine Islands, proves to be a collection of very considerable interest, and well worth a separate report. The first consignment included fifty-two species, four of which, however, were laid aside until additional material could be obtained for comparison; these are described herein. The present lot contains twenty-nine species, fifteen of which (or about half) were not met with before, while of the species represented in the first lot thirty-one (more than half) are not included. A few of the *Challenger* species yet remain to be rediscovered, while several genera, known from both north and south of the islands, have not as yet been discovered there.

*Endoxocrinus alternicirrus* has been rediscovered for the first time, and *Hypalocrinus naresianus*, dredged by the *Challenger* and the *Siboga*, has been again found. *Metacrinus wyvillii*, known from the Kermadec and Ki islands, proves to occur also in the Philippines, while a peculiar comatulid type, first found off the Meangis Islands and later at South Africa, is represented in the collection.

### Family COMASTERIDÆ.

Genus COMASTER L. Agassiz.

COMASTER SENTOSA (P. H. Carpenter).

Obtained at station 5249, Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 23 fathoms.

COMASTER MULTIRADIATA (Linnæus).

A single specimen from station 5249, Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 23 fathoms; has 20 arms (all the II Br series present), with

oblong and strongly overlapping brachials; but the cirrus joints agree with those given for *C. multiradiata* by Carpenter.

A critical study of a very large series shows that *Comatula fimbriata*, *Actinometra borneensis*, and *Actinometra coppingeri* should all be referred to the Linnæan *Asterias multiradiata*.

Other specimens were obtained at stations 5161, between Simaluc Island and Tawi Tawi; 16 fathoms; and 5165, south of San Gasanga Island (Tataan group); 9 fathoms.

#### Genus PHANOGENIA Lovén.

##### PHANOGENIA MULTIBRACHIATA (P. H. Carpenter).

This species was secured a station 5248, Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 18 fathoms; station 5249, same locality; 23 fathoms; and station 5254, same locality; 21 fathoms.

##### PHANOGENIA CARPENTERI (A. H. Clark).

One specimen was dredged at station 5153, east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

This is the species which was described by Prof. Johannes Müller under the name of *Alecto multifida*, which name, however, he explicitly states to be a substitute for *multiradiata* Lamarck, not *multiradiata* Goldfuss. The elements of the III Br series are united by synarthry, and this led Doctor Carpenter to place the species in his "Parvicirra group," corresponding, in part, to the genus *Comanthus*; but all except the II Br series, which are 4 (3+4), are 2, a condition quite unknown in *Comanthus*, the proximal pinnules are slender instead of stout, and terminal combs occur at intervals along the middle and distal pinnules; these combs also are abrupt, with a few long, curved teeth. In spite of the synarthrial instead of syzygial union of the III Br and IV Br series, the affinities of this form are distinctly with the members of the genus *Phanogenia* as restricted, and to that genus it must be assigned.

The specimen at hand has about forty arms.

##### PHANOGENIA MINIMA, new species.

Centro-dorsal stellate, without cirri; radials entirely visible, trapezoidal, proximally twice, distally three times (or rather more), as broad as long; I Br<sub>1</sub> entirely free laterally, four times as broad as long, decreasing slightly in diameter anteriorly; I Br<sub>2</sub> (axillary) broadly pentagonal, twice as broad as long; II Br 4 (3+4), rarely 2; III Br 2 (1+2); IV Br 2 (1+2), but rarely present.

About forty arms 70 mm. long; brachials and pinnules as in *P. gracilis*, but proportionately more slender and delicate.



*Color*.—Chrome yellow, with numerous longitudinal narrow lines on the radial and division series, and transverse lines on the arms, of dark brown.

*Type*.—Cat. No. 25469, U.S.N.M., from *Albatross* station 5108; west of Nasugbu Point, central Luzon (east of Simo Bank); 16 fathoms.

This delicate little species appears to be quite distinct from any of those heretofore described; the absence of regular division series beyond the III Br, these last being 2 (1+2), are sufficient to distinguish it at once. Though very small, the type-specimen has the appearance of being fully developed.

PHANOGENIA DELICATA, new species.

Centro-dorsal large, discoidal, with a broad flat polar area 5 mm. in diameter; cirrus sockets in a single, slightly irregular, marginal row.

Cirri XIII–XIX, 24–25, moderately stout, 20 mm. to 25 mm. long; first joint about twice as broad as long, the following gradually increasing in length to the fourth or fifth, which is as long as broad; next three or four joints one-third to one-half again as long as broad; following joints decreasing in length, the terminal fourteen or fifteen being about twice as broad as long; the second and following joints have their distal dorsal edges slightly prominent; after the seventh or eighth, which is a well-marked transition joint, the distal dorsal edge becomes strongly produced and finely serrate, this production very gradually narrowing anteriorly, at the same time gradually becoming crescentic, and gaining in height; the antepenultimate joint bears a subterminal transverse ridge, bending forward on each side as it decreases in height; opposing spine small, median, erect, transversely elongate, not reaching one-fourth the dorso-ventral diameter of the penultimate joint in height; terminal claw longer than the penultimate joint, moderately stout, evenly tapering, and moderately and evenly curved.

Ends of the basal rays visible as small tubercles in the angles of the calyx, bridging over the narrow clefts between the centro-dorsal and the primary division series; radials only very slightly visible over the ends of the basal rays; I Br<sub>1</sub> almost entirely, or quite, concealed, very short, almost entirely united laterally; I Br<sub>2</sub> (axillary) broadly pentagonal, twice as broad as long, the anterior angle rather produced, the lateral edges free; II Br 4 (3+4), well separated laterally; II Br<sub>2</sub> united for the proximal two-thirds, separated by a broad U-shaped gap distally; III Br 2, very rarely 4 (3+4).

Arms thirty or thirty-one, slender, 70 mm. to 80 mm. long; first two brachials approximately equal, slightly wedge-shaped, about twice as broad as the median length, the first almost entirely united

interiorly; third and fourth brachials (syzygial pair) half again to twice as broad as long, oblong; next three brachials oblong, about twice as broad as long, then becoming wedge-shaped, almost triangular, half again as broad as long, after the proximal third of the arm becoming gradually less obliquely wedge-shaped, though remaining of about the same proportionate length, and in the terminal portion of the arm becoming wedge-shaped, and as long as or longer than broad. The elements of the division series have everted and prominent, finely spinous, distal ends; the brachials have strongly produced and overlapping, finely spinous, distal ends. Syzygies occur between the third and fourth brachials, again between the eleventh and twelfth or twelfth and thirteenth, and distally at intervals of four oblique muscular articulations.

Disk 13 mm. in diameter, with a few scattered calcareous granules about the central anal tube; mouth marginal and radial.

$P_D$  15 mm. long, slender, with forty joints, all approximately as long as broad; terminal comb arising suddenly, with seven teeth, triangular, longer than broad, basally in apposition, rather longer than the diameter of the joints which bear them, rather strongly incurved;  $P_1$  similar, slightly less stout basally, equal in length or slightly longer;  $P_2$  small and weak, 6 mm. long;  $P_3$  similar, but 5 mm. long (twenty joints);  $P_4$  6 mm. or 7 mm. long, considerably stouter than the two preceding pinnules, with the distal ends of the joints strongly produced, and bearing a genital gland; following pinnules slightly stouter, with larger genital glands, and slowly increasing in length; distal pinnules very slender, about 9 mm. long, with about twenty joints, the first two short, then increasing in length to about twice as long as broad and decreasing again in the terminal portion.

*Color* (in spirits).—White, the arms beyond the basal portion with broad broken lateral lines, and dorsal bands, of violet; cirri white, with occasional bands of light violet.

*Type*.—Cat. No. 25463, from *Albatross* station 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

#### Genus COMATULA Lamarck.

##### COMATULA PECTINATA (Linnaeus).

One specimen from station 5152; off Tawi Tawi; 34 fathoms.

## Genus COMATELLA A. H. Clark.

COMATELLA NIGRA (P. H. Carpenter).

This species was obtained at station 5253; Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 28 fathoms.<sup>a</sup>

## Genus COMANTHUS A. H. Clark.

COMANTHUS NOBILIS (P. H. Carpenter).

Specimens were obtained at station 5249; Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 23 fathoms.

Station 5250; same locality; 23 fathoms.

Station 5253; same locality; 28 fathoms; and

Station 5254; same locality; 21 fathoms.

The examples from stations 5249 and 5250, and one of those from station 5254, have each two well-developed cirri.

## COMANTHUS BRIAREUS (Bell).

I have recently been able to study a large series of specimens of this and allied species, and have succeeded in dividing them up into certain specific groups which appear to be circumscribed by definite and well-defined characters, and which will, I believe, stand the test of future investigations.

*Briareus* was first described by Bell from Port Denison, Australia, but he entirely overlooked its very obvious affinities, placing it in the genus "*Antedon*," between two species of *Zygometra*. The division series subsequent to the III Br are described as "two joints, no syzygy," but in the figure most of them are 4 (3+4). Carpenter called attention to both of these errors in 1888, and at the same time described a supposedly new species, *divaricata*, from Banda; *divaricata* differs from *briareus* only in having the centro-dorsal small and stellate, with no trace of cirri, this being in *briareus* a thin disk with from fifteen to twenty partially developed cirri. The present series shows all variations between the two extremes, and it therefore becomes necessary to consider the two identical. The type of *divaricata* is slightly smaller than that of *briareus*, though more developed; but

<sup>a</sup> Under the name of *Antedon bassett-smithi* Professor Bell has described (and, fortunately, figured) a specimen of *Comatella stelligera* from the Macclesfield Bank, just west of the Philippine Islands. He refers this supposed new species to Carpenter's "*Spinifera* group," and discourses at great length upon the "extraordinary divergences exhibited by the syzygies of this species." Had the "species" been referred to the "*Stelligera* group" of "*Actinometra*," instead of to the "*Spinifera* group" of "*Antedon*," this peculiarity, as well as all the other supposed peculiarities, would have been found to be quite normal. Being now correctly identified, there is no longer any danger that "*Antedon*" *bassett-smithi* "will severely shake our faith in the value of the site of the syzygy as an aid in specific diagnosis."



the difference is not great, and the size at which any given comasterid may become mature is always variable. Carpenter's *magnifica*, from the Philippine Islands, is very close to *briareus*, representing merely a somewhat more advanced stage along the same phylogenetic line, and many specimens of the latter approach it more or less; but *magnifica* is sufficiently well marked off to retain its present status as a distinct species.

The Philippine specimens referred to *briareus* were compared with a typical Australian example and no differences were found.

The *Albatross* dredged *Comanthus briareus* at station 5138; between Jolo and Pangasinan islands; 19 fathoms.

Station 5142; north of Jolo (town); 21 fathoms.

Station 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.

Station 5148; Rakiputan Strait; between the north end of Samal Island and the west coast of Davao Bay; 18 fathoms.

Station 5249; same locality; 23 fathoms; and

Station 5254; same locality; 21 fathoms.

COMANTHUS POLYCNEMIS, new species.

In my previous list I referred, rather doubtfully, to *Comanthus alternans*, a specimen resembling *C. briareus* in all respects, except that the division series distal to the II Br are 2 until the last division series is reached, which is usually 4 (3+4). The present collection contains numerous examples of the same form which appears to be quite constant, and I therefore propose to recognize it under the name of *Comanthus polycnemis*. It may be diagnosed as follows:

Centro-dorsal pentagonal or stellate, with no trace of cirri; general build and proportions as in *C. briareus*; rays dividing four to six (usually four or five) times; II Br 4 (3+4); subsequent divisions 2, except that the outermost divisions, especially on the outer side of each III Br series, are usually 4 (3+4).

The scarcity of 4 (3+4) division series, which, though always present, are confined to the outer parts of the rays, distinguish this species at once from all others. Bell's *variabilis*, and the *multifida* of Müller and Carpenter, placed by the latter in the "Parvicirra group," and therefore presumably considered by him as near *briareus*, belong in reality to the genus *Phanogenia* and are near *P. typica*.

*Type*.—Cat. No. 25467, U.S.N.M., from *Albatross* station 5249; Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 23 fathoms.

The *Albatross* dredged this species at—

Station 5139; between Jolo and Pangasinan Islands; 20 fathoms.

Station 5147; off Balinpongpong Island (south of Jolo); 21 fathoms.



Station 5248; Rikiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 18 fathoms.

Station 5249; same locality; 23 fathoms.

Station 5250; same locality; 23 fathoms.

Station 5251; same locality; 20 fathoms.

Station 5252; same locality; 28 fathoms.

Station 5253; same locality; 28 fathoms.

Station 5254; same locality; 21 fathoms.

There are also specimens with no definite locality given.

One of the specimens from station 5249 is four rayed.

*COMANTHUS DUPLEX* (P. H. Carpenter).

A single specimen was secured at station 5252; Rikiputan Strait, between the northern end of Samal Island and the western coast of Davao Bay; 28 fathoms.

*COMANTHUS ROTALARIA* (Lamarck).

This species was found at station 5218, east of the northern end of Burias Island (south of Luzon); 20 fathoms.

Station 5248; Rikiputan Strait, between the northern end of Samal Island and the western coast of Davao Bay; 18 fathoms.

Station 5253; same locality; 28 fathoms; and

Station 5254; same locality; 21 fathoms.

*COMANTHUS ALTERNANS* (P. H. Carpenter).

One specimen was dredged at station 5252; Rikiputan Strait, between the northern end of Samal Island and the western shore of Davao Bay; 28 fathoms; and another at station 5254; same locality; 21 fathoms.

Family *HIMEROMETRIDÆ*.

Genus *PONTIOMETRA* A. H. Clark.

*PONTIOMETRA INSUPERATUS*, new species.

Centro-dorsal hemispherical, the dorsal pole small, slightly convex; cirrus sockets arranged roughly in three alternating rows, more or less crowded.

Cirri XX, 41-52, 30 mm. long, stout, but tapering in the distal half, and comparatively slender at the tip; first joint three times as broad as long, second and third twice as broad as long, the following gradually increasing in length to about the seventh, which is about one-third broader than long; next three or four similar, the joints then gradually decreasing in length, those in the distal third of the cirrus being uniformly twice as broad as long; sixth to eighth and following joints with the distal dorsal edge everted in the shape of an open V-shaped ridge, composed of an apical round tubercle, and two lateral more or less elongate tubercles; distally this ridge gradually becomes less and less V-shaped, composed of four or five tubercles,

the apical tubercle, however, remaining in the same position, and therefore occupying a place below the center of the now almost straight tubercular ridge; as the joints decrease in length distally, the apical tubercle gradually disappears, and the transverse ridge moves gradually to a median position; on becoming median, it at first has usually four tubercles, this being later reduced to three, while beginning on about the fifteenth from the end there are only two, the last three or four joints before the penultimate bearing only a single median tubercle; opposing spine comparatively large, arising from the entire dorsal surface of the joint, the apex subterminal, equal to about half the diameter of the penultimate joint in height; terminal claw somewhat longer than the penultimate joint, rather stout, and strongly curved.

Ends of the basal rays not visible; radials short in the median line, but extending far up into the angles of the calyx, reaching the disk, and separating the bases of the I Br<sub>1</sub>; I Br<sub>1</sub> slightly trapezoidal, about twice as broad basally as long, very widely separated laterally, well rounded dorsally; I Br<sub>2</sub> (axillary) pentagonal, about as long as broad; II Br 2, one series only being present.

Arms eleven in number (in the type), very widely separated. All the arms are broken off at the syzygy between the third and fourth brachials. First brachial slightly wedge-shaped, half again as broad as long, interiorly united for the anterior half or two-thirds, diverging distally as approximately a right angle; second brachial nearly square; third (hypozygal) oblong, three times as broad as long.

P<sub>1</sub> slender, 15 mm. long, evenly tapering, with twenty to twenty-five joints, the first twice as broad as long, the second and third squarish, the following about twice as long as broad, shorter terminally.

*Color*.—Purplish brown.

*Type*.—Cat. No. 25468, U.S.N.M., from *Albatross* station 5145; off Jolo town; 23 fathoms.

#### Genus CENOMETRA A. H. Clark.

##### CENOMETRA DELICATA, new species.

Centro-dorsal discoidal, the polar area slightly concave; cirrus sockets marginal, arranged in two closely crowded alternating rows.

Cirri XIX, 31–33, 20 mm. long, comparatively slender; first joint short, the remainder subequal, about twice as broad as long; joints somewhat flattened dorsally, after the tenth bearing very small blunt paired median dorsal tubercles; opposing spine triangular, arising from the entire surface of the penultimate joint, blunt, the apex median in position; terminal claw about as long as the penultimate joint, rather stout and strongly curved.

Ends of the basal rays visible as flattened tubercles in the angles of the calyx, but difficult to differentiate from the centro-dorsal;

radials visible, but short; slightly divergent distally; I Br<sub>1</sub> trapezoidal, decreasing slightly in diameter anteriorly, proximally about two and one-half times as broad as long; I Br<sub>2</sub> (axillary) broadly pentagonal, about twice as broad as long, the lateral edges about as long as those of the I Br<sub>1</sub>; II Br 2; III Br 2; IV Br 2, only found on the outer side of the I Br series; all the joints to and including the second brachial with prominent lateral processes, the outer edges of which form a line parallel to the axis of the division series.

Thirty-five arms (in the type) 85 mm. long, more slender than in the other species of the genus; brachials as in *C. unicornis*, but proportionately slightly longer.

The pinnules are in general like those of *C. unicornis*, but P<sub>2</sub> is much more slender, 9 mm. long, with sixteen or seventeen joints, the first nearly twice as long as broad, becoming squarish on the third, and then gradually becoming about one-third longer than broad; from the fourth onward the distal dorsal edge of the joints is strongly produced, standing out in the form of a coarsely spinous crescentic ridge.

*Color*.—Deep violet, the cirri, P<sub>2</sub>, and the dorsal side of the other pinnules, bright yellow.

*Type*.—Cat. No. 25465, U.S.N.M., from *Albatross* station 5248; Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 18 fathoms.

Another specimen, entirely deep violet, with thirty-four arms, was dredged at station 5249; same locality; 23 fathoms.

CENOMETRA UNICORNIS (A. H. Clark).

Two fragmentary specimens from station 5108; west of Nasugbu Point (off Simo Bank) central Luzon; 16 fathoms.

Genus STEPHANOMETRA A. H. Clark.

STEPHANOMETRA TENUIPINNA (Hartlaub).

One mutilated specimen was dredged at station 5174; off Jolo town; 20 fathoms.

Genus CYLLOMETRA A. H. Clark.

CYLLOMETRA MANCA (P. H. Carpenter).

One specimen from station 5154; off Tawi Tawi (between Simalue and Tawi Tawi); 12 fathoms; and others from station 5212; off Masbate; 80 fathoms.

Genus OLIGOMETRA A. H. Clark.

OLIGOMETRA PULCHELLA A. H. Clark.

One small mutilated specimen from station 5248; Rakiputan Strait, between the northern end of Samal Island and the west coast of Davao Bay; 18 fathoms.



## Family TROPIOMETRIDÆ.

Genus CALOMETRA A. H. Clark.

CALOMETRA CARDUUM A. H. Clark.

One fine specimen from station 5166; off Simonor Island; 97 fathoms.

Genus PTILOMETRA A. H. Clark.

PTILOMETRA PULCHERRIMA, new species.

Centro-dorsal large, columnar, the sides parallel, terminated by a group of five large tubercles each radial in position, arising from an otherwise flat polar area; small circular space bounded by the ends of these tubercles light in color, this light color extending in interradian lines between the summits of the tubercles and thence to the periphery of the polar area; cirrus sockets arranged in ten columns of three or four each, the radial areas being separated from each other by a low, rounded ridge, and the pairs of columns in each radial area being separated by a broad, shallow groove about twice as broad as the rounded interradian ridges. The centro-dorsal is 5 mm. long and 6 mm. in diameter.

Cirri long and slender, XXXV, 80-85 (the less developed as few as 68), 75 mm. to 80 mm. long; first joint short, second about twice as broad as long, the following gradually increasing in length to the sixth or seventh, which is as long as broad; following fifteen to twenty joints between one-third and one-half again as long as broad, then very slowly decreasing in length, the terminal thirty to thirty-five joints being about twice as broad as long; the cirri are somewhat compressed distally; after the seventeenth to the twentieth joint the median part of the distal dorsal edge begins to project as a sharp and slender spine, directed diagonally forward; this spine gradually increases in length, at the same time arising from more and more of the dorsal surface of the joints, on the short distal joints arising from their entire dorsal surface, with a slightly convex proximal and more strongly concave distal edge, equaling in height about one-half the vertical diameter of the joints; terminal eight or ten joints tapering rather rapidly, at the same time increasing slightly in proportionate length, so that the antepenultimate and penultimate joints are very small and about as long as broad; opposing spine equal in length to the diameter of the penultimate joint, blunt, the distal edge forming a straight line with the distal edge of the penultimate joint, arising from nearly or quite the whole of the dorsal surface of that joint; terminal claw slightly longer than the penultimate joint, comparatively stout and strongly curved.

Disk naked; all but one of the ambulacra (which divides immediately) are given off in well-separated pairs, so that nine ambulacral



grooves reach the mouth; brachial ambulacra naked; pinnule ambulacra with small but well developed side and covering plates.

Ends of the basal rays visible as small tubercles in the angles of the calyx; radials short, of approximately uniform width all around the calyx, slightly convex proximally and correspondingly concave distally; I Br<sub>1</sub> oblong, three times as broad as long, in close apposition laterally, with an indicated broad rounded median keel; I Br<sub>2</sub> broadly pentagonal, two and one-half times as broad as long, the lateral edges about half as long as those of the I Br<sub>1</sub>, in close lateral apposition and sharply flattened; II Br 2, resembling the I Br, but proportionately slightly longer, with the same indicated broadly rounded median keel, sharply flattened laterally and in close apposition.

Twenty arms 100 mm. long; first two brachials slightly wedge-shaped, about twice as broad as long, sharply flattened and in close apposition exteriorly, the first closely united interiorly, the second in close apposition and flattened interiorly; third and fourth brachials (syzygial pair) oblong, about one-third broader than long; next four or five brachials oblong, about three times as broad as long, then becoming wedge-shaped, and after the twelfth or fifteenth triangular, two and one-half times as broad as long, in the terminal part of the arm wedge-shaped again and slightly longer, the arm ending abruptly with six or seven very small and short brachials, and curving inward between the terminal pinnules, which exceed the arm in length by 4 mm.; arms broadly convex dorsally in their basal portion (the first seven or eight brachials sharply "wall-sided"), very gradually becoming narrower, and distally strongly carinate; at about the twelfth or fifteenth brachial a broadly rounded median keel begins to be indicated; this gradually narrows distally, and on the twentieth to the twenty-fifth the median portion of the distal edge begins to be slightly prominent; this increases slowly in extent at the same time narrowing, so that brachials in the outer half of the arm are bluntly carinate, with the median portion of the distal edge produced, and in the terminal portion sharply carinate, with prominent overlapping spines.

P<sub>1</sub> 8 mm. long, strongly prismatic, slightly less stout than the succeeding pinnules, with sixteen joints, the first short, the second and third squarish, the remainder very slightly longer than broad, becoming about one-third again as long as broad distally. P<sub>2</sub> 12.5 mm. long, with nineteen joints, the first twice as broad as long, the second squarish, the remainder very slightly longer than broad; the more distal joints exhibit a tendency toward a slight production of their distal edges at the prismatic angles; the terminal three or four joints taper rather more rapidly than usual. P<sub>3</sub> 14 mm. long, with seventeen joints, the first twice as broad as long, the second squar-

ish, then very gradually becoming longer than broad, and twice as long as broad in the terminal portion; the last six joints taper rather rapidly, and the last two joints are minute; from the fourth joint onward small spines are developed on the distal border, on the distal angle of the pinnule, and the last four joints have, in addition, a somewhat longer spine developed on the corresponding interior angle.  $P_1$ , 15 mm. long, with sixteen joints, all but the basal proportionately longer than those of  $P_{10}$ , the distal with long spines on their prismatic angles;  $P_5$  similar, slightly longer;  $P_6$  similar, 17 mm. long;  $P_{10}$  is 19 mm. long, with twenty joints, becoming elongate distally, with long spines at the prismatic angles; in the terminal part of the arms the pinnules slowly decrease in length. The abrupt distal taper gives the pinnules the appearance of having been broken off at the tip and subsequently repaired.

*Color*.—Yellow-brown.

*Type*.—Cat. No. 25466, U.S.N.M., from *Albatross* station 5252; Rakiputan Strait, between the northern end of Samal Island and the western shore of Davao Bay; 28 fathoms.

### Family THALASSOMETRIDÆ.

#### Subfamily THALASSOMETRINÆ.

#### Genus STENOMETRA A. H. Clark.

##### STENOMETRA ARACHNOIDES, new species.

Centro-dorsal moderate, columnar, broader basally than long, decreasing slightly in diameter distally, the bare polar area 2 mm. in diameter; cirrus sockets arranged in ten columns of two each, closely crowded.

Cirri XX (XII in the type), 61–65, 30 mm. long; first four joints subequal, averaging twice as broad as long, rather prominently overlapping all around; fifth joint nearly half again as long as broad, a more or less marked transition joint; sixth joint about the same length or slightly shorter; next five joints approximately squarish, then gradually decreasing in length, those in the distal half of the cirrus being twice as broad as long, or even slightly shorter; the fourteenth or fifteenth and following joints bear prominent dorsal spines.

Disk and ambulacra well plated.

Ends of the basal rays visible as dorso-ventrally elongate tubercles in the angles of the calyx; radials concealed, or with the distal, coarsely spinous, margin just visible over the ends of the basal rays; I  $Br_1$  very narrow, chevron shaped, with abruptly everted, coarsely spinous edges, in close apposition laterally; I  $Br_2$  (axillary) rhombic, twice as broad as long, the edges concave, abruptly everted and coarsely spinous all around, a high sharp median keel in the proximal two-thirds.

Arms ten, but all broken off near the base; first two brachials externally, and second and third internally, sharply flattened laterally; first brachials interiorly united; second brachial large, shield-shaped, deeply incising the very narrow first brachial; first two brachials with more or less everted and coarsely spinous edges; arms with a very narrow, sharp, and moderately high median carination.

The pinnules are essentially as in *S. hana*.

*Color*.—Chrome yellow.

*Type*.—Cat. No. 25470, U.S.N.M., from *Albatross* station 5154; off Tawi-Tawi (between Simaluc and Tawi-Tawi); 12 fathoms.

A much mutilated specimen found in a jar with a specimen of *Amphimetra discoidea* (and therefore probably taken in shallow water), from Port Denison, Australia, certainly belongs to this genus, and possibly to this species. It is slightly smaller than the type, with the keels less produced, and with the spinous edges of the lower joints less pronounced, differences which are in all probability due to immaturity.

The occurrence in the East Indian region of a littoral species of Thalassometridæ, a family there and elsewhere especially characteristic of the deep-water "Oceanic" faunal division, is a fact of very considerable interest.

#### CROTALOMETRA, new genus.

Centro-dorsal large, conical, as long as or longer than broad, the cirrus sockets large, arranged in two columns of usually two each in each radial area.

Cirri X-XX, 60-80, very long and strongly flattened; first five joints short, then longer than broad, becoming short again distally; distal joints with the distal dorsal edge produced; all the joints with the edge all around somewhat prominent.

Ends of basal rays visible as small tubercles in the angles of the calyx; radials short and bandlike, of uniform height, or concealed; I Br of moderate length, rounded dorsally, in close lateral apposition and strongly wall sided, the lateral edges everted.

Ten to twenty arms; II Br 4(3+4); first two brachials in close lateral contact, and sharply flattened, the lateral edges everted; first four brachials in close apposition and sharply flattened interiorly; arms stout and rugged; first nine or ten brachials oblong, about twice as broad as long, tubercular; following brachials triangular, about as long as broad, becoming wedge-shaped and somewhat longer than broad terminally. Syzygies occur between the third and fourth brachials, again between the fourteenth-fifteenth to seventeenth-eighteenth, and distally at intervals of four to ten (usually six or seven) oblique muscular articulations.



P<sub>1</sub> large and stout, but becoming slender distally, strongly flattened exteriorly; following pinnules decreasing rapidly in stoutness, and somewhat in length; distal pinnules stout, strongly prismatic, longer than P<sub>1</sub>.

*Color*.—Yellow.

*Genotype*.—*Crotalometra eupedata*.

Carpenter's *Antedon valida*, the systematic position of which has puzzled me greatly, belongs to this genus, and is closely related to *C. eupedata*, though apparently perfectly distinct; *Antedon incerta* also should be referred to this genus. The *Antedon magnicirra* described from South Africa by Professor Bell is likewise a member of this genus, and I have examined two or three additional species from the East Indian region.

CROTALOMETRA EUPEDATA, new species.

Centro-dorsal large, conical, 5 mm. long and 5 mm. broad at the base, the bare polar area forming the apex of the cone; cirrus sockets arranged in ten columns, one at the outer side of each radial area, so that the cirrus columns of adjacent radial areas are in close apposition, the two columns in each area being separated by a space about equal to their own width; one or two cirrus sockets to each column, usually succeeded by one or two obsolete and more or less obliterated ones.

Cirri X-XX, 66, 90 mm. long; first three joints two and one-half times as broad as long; fourth twice as broad as long; fifth half again as broad as long; sixth slightly longer than broad; seventh a transition joint, dull in the anterior three-fourths, highly polished and flattened in the distal fourth, not quite twice as long as broad; eighth to eleventh or twelfth joints about twice as long as broad, then gradually decreasing in length, becoming squarish about the twentieth, and twice as broad as long distally; after the fifteenth joint, the distal dorsal edge begins to project slightly, though this is scarcely noticeable until the twentieth is reached, after which it increases in height, becoming more sharply rounded in end view, and arises gradually from the whole dorsal surface of the joint, so that the dorsal profile of the terminal third of the cirrus is strongly serrate; opposing spine a blunt tubercle, the apex subterminal, arising from the whole dorsal surface of the penultimate joint; terminal claw very long and slender, twice as long as the penultimate joint, only slightly curved; all the cirrus joints have the distal ends all around slightly projecting and very finely spinous, making the cirri rough to the touch; this projection is slightly more marked on the ventral side than laterally.

Disk covered with small plates, very thickly set near the ambulacra, but becoming more scattered toward the periphery in the interambulacral areas; disk ambulacra lined with large regular plates;



plating on brachial and pinnule ambulaera very highly developed; perisome of the arms completely covered with rather large inter-brachial plates, so that the arms and pinnules, when the covering plates are closed, are completely encased in a calcareous covering.

Ends of the basal rays visible as small, though prominent, tubercles in the angles of the calyx; radials of uniform width all around the calyx, short, somewhat over four times as broad as long, the anterior edge set with small scattered spines; I Br<sub>1</sub> short, of uniform height, the posterior border convex, the anterior concave, about three times as broad as long, the posterior edge slightly prominent, the lateral edges in very close apposition, and rather prominently everted, the crest of the resultant ridge finely spinous; I Br<sub>2</sub> broadly pentagonal, the lateral edges about as long as those of the I Br<sub>1</sub>, about twice as broad as long, the lateral edges everted and finely spinous like those of the I Br<sub>1</sub>; like the I Br<sub>1</sub> and the first two brachials it bears a single small rather prominent rounded tubercle near each lateral margin.

Arms ten, stout and rugged, gradually becoming slender distally, 150 mm. long; first brachial longer exteriorly than interiorly, concave anteriorly, the interior edges closely united, the exterior in close apposition, everted and spinous like those of the preceding joints; second brachial about twice as large, irregular in shape, strongly convex posteriorly, in close apposition and strongly flattened with everted and spinous edges, both exteriorly and interiorly; third and fourth brachials (syzygial pair) half again as broad as long, flattened exteriorly and interiorly, the edges less everted than those of the preceding joints; following five brachials approximately oblong, rather strongly tubercular, about three times as broad as long, after the twelfth becoming triangular, about as long as broad, this proportion remaining unchanged until near the arm tips, where the brachials become wedge-shaped, and somewhat longer; the distal edges of the brachials in the outer two-thirds of the arm are overlapping and finely spinous. Syzygies occur between the third and fourth brachials, again between the fourteenth-fifteenth to seventeenth-eighteenth, and distally at intervals of four to ten (usually six or seven) oblique muscular articulations.

P<sub>1</sub> large and very stout, strongly flattened exteriorly, with seventeen or eighteen joints all broader than long; the pinnule tapers rather rapidly after the proximal third, so that the terminal portion is delicate, with very small joints; P<sub>2</sub> 7 mm. long, stout basally, though not nearly so stout as P<sub>1</sub>, tapering rapidly, so that the distal half is slender; it is composed of fourteen joints, the first three broad, the fourth about as long as broad, the remainder somewhat longer than broad; the first six joints of P<sub>1</sub> have the distal side very strongly concave, forming two sharp keels, one external along the

flattened outer side, the other internal; the external keel is armed with fine spines; the distal joints are prismatic, with the angles somewhat produced;  $P_2$  has a similar double carination, but, while the exterior keel is much lower, it persists in a raised and very spinous line to the tip of the pinnule; the ends of the distal joints are much more spinous than in  $P_1$ ;  $P_3$  6 mm. long, more slender than  $P_2$ , being in about the same proportion to that pinnule as it is to  $P_1$ , with twelve joints, at first broad, becoming about as long as broad at the fifth, and longer than broad distally; the pinnule is strongly prismatic, the ridges and the distal ends of the joints being spinous; but the two basal keels are only slightly marked;  $P_4$  and the following pinnules from  $P_5$  onward similar to  $P_3$ , but slightly more slender, with the joints proportionately slightly longer; distal pinnules 12 mm. long, rather stout, strongly prismatic, with eighteen joints, the first crescentic, the second strongly trapezoidal, about as broad as its greater length, the remainder about half again as long as broad; the external ridge is somewhat produced, and finely spinous.

*Color*.—Bright yellow, the cirri lighter.

*Type*.—Cat. No. 25462, U.S.N.M., from *Albatross* station 5236; off the east coast of Mindanao, north of Lianza Bay; 494 fathoms.

A young specimen with arms 60 mm. long was dredged at Station 5116; north of Maricaban Island (between Luzon and Mindoro); 200 fathoms; it possesses one II Br series of 4(3+4).

#### Genus PARAMETRA A. H. Clark.

##### PARAMETRA COMPRESSA (P. H. Carpenter).

One specimen from station No. 5255; off Davao (town); 100 fathoms; and another very fine example from station 5166; off Simonor Island; 97 fathoms.

#### Subfamily CHARITOMETRINÆ.

#### Genus PACHYLOMETRA A. H. Clark.

##### PACHYLOMETRA LEVIGATA, new species.

Centro-dorsal thick-discoidal or more or less columnar, the polar area flat, 2.5 mm. or 3 mm. in diameter; cirrus sockets arranged in three columns in each radial area, the two outer columns converging distally, usually meeting beyond the middle column; columns usually separated by more or less developed ridges.

Cirri XXX-XXXV, 14-15, 15 mm. long; first two joints about twice as broad as long; third joint about as long as broad; fourth to seventh or eighth half again as long as broad, then gradually decreasing distally, the third and fourth from the end being only

slightly longer than broad; the terminal joints are again about half again as long as broad; distal ventral ends of the joints slightly prominent; distal dorsal ends of the outer joints sometimes slightly thickened; opposing spine minute, terminally situated, directed obliquely forward, often barely indicated or altogether absent; terminal claw nearly as long as the penultimate joint, moderately slender and moderately curved.

Disk completely covered with a pavement of small plates; brachial and pinnule ambulacra well plated; large irregular plates over the genital glands.

Ends of the basal rays usually visible as dorso-ventrally elongate tubercles in the angles of the calyx, but sometimes quite concealed; radials concealed; I Br<sub>1</sub> usually entirely concealed in the median line, slightly visible over the ends of the basal rays, sometimes visible as a narrow line along the proximal border of the I Br<sub>2</sub>; I Br<sub>2</sub> rhombic, twice as broad as long, all the sides somewhat incurved, rising in the proximal half to a large rounded tubercle; II Br 4 (3+4), rarely 2, in close apposition and strongly flattened laterally.

Arms twelve to fourteen, 100 mm. long; first eight or nine brachials wedge-shaped or almost oblong, about twice as broad as long, more or less tubercular, then becoming triangular, about as long as broad, in the terminal portion of the arm wedge-shaped and longer than broad. Syzygies occur, in arms springing direct from a I Br axillary, between the third and fourth brachials, again between the fourteenth and fifteenth or fifteenth and sixteenth, and distally at intervals of six to sixteen oblique muscular articulations; in arms springing from a II Br axillary the first syzygy is between the first and second or second and third brachials.

The pinnules resemble those of *P. angusticalyx*, but the expansion of the genital pinnules is somewhat more marked.

*Color*.—Yellow.

*Type*.—Cat. No. 25464, U.S.N.M., from *Albatross* station 5236; off the eastern coast of Mindanao, north of Lianza Bay; 494 fathoms.

#### Genus GLYPTOMETRA A. H. Clark.

##### GLYPTOMETRA TUBEROSA (P. H. Carpenter).

I tentatively refer to this species a very young specimen from station 5236; off the eastern coast of Mindanao, north of Lianza Bay; 494 fathoms. The lateral eversion of the I Br and lower brachials is very pronounced, and the median carination characteristic of *tuberosa* is indicated on the I Br and lower brachials; tubercles, however, have not as yet appeared. This specimen is remarkable for the extraordinary size of the external ends of the basal rays.



## Family ANTEDONIDÆ.

Genus IRIDOMETRA A. H. Clark.

IRIDOMETRA EXQUISITA, new species.

Centro-dorsal hemispherical, nearly covered with cirrus sockets, a very small convex polar area bare.

Cirri XL-L, 14-15, exceedingly slender and thread-like, 10 mm. long; first joint short, second half again to twice as long as broad, the following very greatly elongated, becoming shorter again on the antepenultimate, which is three times as long as broad, and the penultimate, which is twice as long as broad; the latter decreases slightly in diameter distally, and may bear a minute terminal opposing spine, though this is usually absent; terminal claw about three-quarters the length of the penultimate joint, slender, and slightly curved; the articulations of the joints are greatly expanded, except in the terminal five or six.

Radials even with the edge of the centro-dorsal; I Br<sub>1</sub> short, deeply incised in the median line, in contact basally; I Br<sub>2</sub> (axillary) rhombic, twice as broad as long, the anterior angle produced.

Ten arms, 40 mm. long; first brachial much longer outwardly than inwardly, very deeply incised by the second brachial, barely in contact basally over the anterior angle of the I Br<sub>2</sub>; third and fourth brachials (syzygial pair) slightly longer interiorly than exteriorly, about as broad as long exteriorly; next four brachials oblong, about twice as broad as long, then becoming triangular, about as long as broad, after the end of the proximal third becoming obliquely wedge-shaped, rather longer than broad, and very gradually increasing in length distally. Syzygies occur between the third and fourth brachials, again between the ninth and tenth and fourteenth and fifteenth, and distally at intervals of three oblique muscular articulations.

P<sub>1</sub> 6 mm. long, moderately stout basally, becoming slender distally, somewhat stiffened, with thirteen joints; first joint twice as broad as long, second half again as long as broad, third and following three or three and one-half times as long as broad, becoming slightly shorter terminally; P<sub>2</sub> similar, but more slender, 3 mm. long, with nine joints, the first twice as broad as long, the second slightly longer than broad, the third twice as long as broad, the remainder greatly elongated; P<sub>3</sub> 2 mm. long, with eight joints, not tapering so rapidly as P<sub>2</sub> (therefore appearing somewhat stouter), and bearing a small genital gland in the distal portion; the joints have slightly overlapping distal ends; following pinnules similar; distal pinnules 6 mm. long, similar to those in other species of the genus.

*Color* (in spirits).—White, with blotches of brown on the arms and pinnules; perisome brown.

*Type*.—Cat. No. 25471, U.S.N.M., from *Albatross* station 5178; north of Tablas Island; 78 fathoms.



## Family PENTACRINITIDÆ.

Genus ENDOXOCRINUS A. H. Clark.

ENDOXOCRINUS ALTERNICIRRUS (P. H. Carpenter).

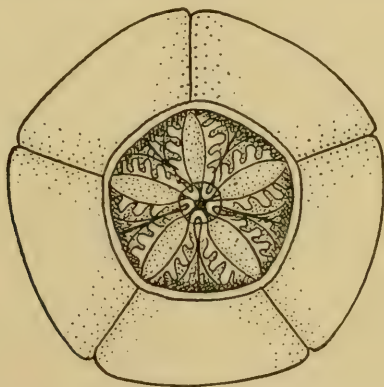
Two fine specimens of this interesting species were dredged at station 5236; off the eastern coast of Mindanao, north of Lianza Bay; 494 fathoms; one has thirty, the other thirty-one arms, 115 mm. long from the basals. They agree perfectly with Carpenter's description and figure, and with the *Challenger* specimen in the U. S. National Museum. The color is a slightly brownish white.

Carpenter included as uncertain *Challenger* station 210, off Panglao and Siquijor (375 fathoms), in his list of localities; the rediscovery of the species in the Philippine Islands suggests that he was right in referring his unlabeled specimens to this station.

Genus HYPALOCRINUS A. H. Clark.

HYPALOCRINUS NARESIANUS (P. H. Carpenter).

Three specimens, each with arms about 150 mm. long, were secured at station 5236; off the eastern coast of Mindanao, north of Lianza



RADIALS, BASALS, AND INFRABASALS OF HYPALOCRINUS NARESIANUS.

Bay; 494 fathoms. They agree perfectly with a specimen at hand from the *Challenger* collection which possibly was taken off Panglao and Siquijor in 375 fathoms. The peculiar dorso-ventral flattening of the short proximal cirrus joints, and the double dorsal tubercles on the more distal joints, characteristic of the genus, are well marked. The terminal 30 mm. to 35 mm. of the arms have only rudimentary pinnules, so that the arms present the same curious "rat-tailed" appearance considered by Carpenter as especially characteristic of *Metacrinus*. This condition is exhibited by the two specimens figured by Prof. Döderlein which were obtained by the *Siboga* off Celebes;

but in the two *Challenger* specimens I have examined the arm tips are broken off, as delineated in all Carpenter's figures.

One of the specimens was dissected to determine the presence or absence of infrabasals. They were found to be present, resembling closely those of *Isocrinus decorus*.

Genus METACRINUS P. H. Carpenter.

METACRINUS WYVILLII P. H. Carpenter.

One broken specimen from station 5236; off the eastern coast of Mindanao, north of Lianza Bay; 494 fathoms.

It agrees well with a specimen taken near the Kermadec Islands in 630 fathoms, in the U. S. National Museum.

## DESCRIPTIONS OF SOME BEES IN THE U. S. NATIONAL MUSEUM.

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By T. D. A. COCKERELL,  
*Of the University of Colorado, Boulder.*

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The late Doctor Ashmead described many genera of bees, some of which were based on species hitherto unknown. The descriptions were mostly in the form of tables, and in several cases the new species were merely mentioned by name, the detailed descriptions being reserved for a later occasion. Owing to the pressure of other work and Doctor Ashmead's illness, the opportunity for preparing the projected descriptions never came, and in consequence the species concerned remained very imperfectly known. Through the kindness of the National Museum authorities, I have been allowed to borrow the principal species referred to, and accordingly offer detailed descriptions of them. In the cases of the species of *Micrandrena*, *Crociaspidia*, *Perditomorpha*, and *Cænonomada*, although Ashmead gave no separate specific descriptions, he published enough information in the course of the generic diagnoses to satisfy the technical requirements, and the specific names must be credited to him and dated from 1899.

I have added some notes on the Philippine Island bees described by Doctor Ashmead, which I examined a few years ago when in Washington.

### Genus CÆNONOMADA Ashmead.

#### CÆNONOMADA BRUNERI Ashmead.

*Cænonomada bruneri* ASHMEAD, Trans. Amer. Ent. Soc., XXVI, 1899, p. 68 (no locality given).

*Tetrapedia gaullei* VACHAL, Revue d'Entomologie, January, 1904, p. 22. (Tucuman, Argentine.)

*Male*.—Length about 10 mm.; black and lemon yellow; hair of head and thorax above very pale fulvous, of cheeks, pleura, etc., white; wings dusky, the nervures and stigma ferruginous. Head broad; eyes large and prominent, pale green, converging below; facial quad-

range higher than its breadth in middle; labrum, basal half of mandibles, clypeus except upper part (where the lower edge of the black has the outline of a very broad **W**), a triangular supraclypeal mark, lateral face marks narrowing to a point on orbit nearly level with anterior ocellus, and line along posterior orbits, all yellow; scape much dilated, yellow with a large black triangle on one side above; flagellum ferruginous, strongly blackened above, reaching about to anterior part of scutellum, the apical joint attenuated and directed to one side at end, forming a sort of hook; second antennal joint sunken in apex of scape; third much longer than fourth, though not long; ninth and tenth more or less tuberculate beneath; mandibles with a strong inner tooth; tongue long and slender, its length about 4, 165 $\mu$ ; labial palpi normal for the genus, four-jointed, second joint about 765  $\mu$  long, first about 1,920  $\mu$ ; blade of maxilla elongated, broad basally, but the apical two-thirds slender, with small erect bristles along the inner edge; maxillary palpi six-jointed, the first three joints at least twice as thick as the other three, the first less than half length of second; lengths of joints in  $\mu$ : (1) 102, (2) 255, (3) 255, (4) 204, (5) 170, (6) 136; maxillary comb very strongly developed,<sup>a</sup> paraglossæ about 1,020  $\mu$  long, thus much shorter than first joint of labial palpi; mesothorax and scutellum dull, yellowish-brown, the hind part of scutellum dull orange; pleura and metathorax black, the pleura shining with sparse punctures; postscutellum yellow, as also upper edge of prothorax, interrupted in the middle, two short stripes on anterior middle of mesothorax, a dull spot above each tegula, and small spots on axillæ; tubercles orange, strongly produced and pointed; tegulae fulvous, rather large; stigma small; marginal cell broadly rounded at end; basal nervure meeting transversomedial; third submarginal cell longest, receiving second recurrent nervure at beginning of its last third; second submarginal broad, almost if not quite as long below as first, and receiving first recurrent nervure beyond the middle; third transversocubital nervure strongly and abruptly bent; tibiae all yellow (hind tibiae black at extreme base); anterior and middle femora yellow, partly black above; hind femora greatly swollen and thickened, bulging beneath near base, black, with a broad yellow stripe on outer side; hind tibiae thick but not conspicuously abnormal, but with an extremely large and broad dark ferru-

<sup>a</sup> The mouth-parts are described from a slide-mount made by Mr. Crawford. Compared with *Eromalopsis* (*E. solani* Cockerell), the paraglossæ of *C. bruneri* are much longer, the tongue is longer, and the maxillary palpi are very much shorter in comparison with the blade or galea, being hardly half its length, whereas in the *Eromalopsis* the palpus is little shorter than the galea. The maxillary blade of *C. bruneri* shows some approach to the condition found in *Entechnia*.



ginous spur; anterior basitarsus yellow and the small joints ferruginous, both with dense white hair behind; middle basitarsus yellow with the apex black, the small joints dark, the last ferruginous; hind basitarsus black, broadened and flattened, with short dark fuscous hair on inner side; small joints of hind tarsi dark, the first three with successively decreasing pencils of fuscous hair; abdomen yellow, with the hind margins of the segments very broadly black, so that in the middle line there is more black than yellow; extreme base of fifth segment black (probably also the others, were they uncovered); apical plate broadly truncate, yellow with the apex broadly and the sides very narrowly black; venter yellow at sides and black in the middle.

*Female*.—More robust, but very similar in general appearance. Scutellum and lateral margins of mesothorax dull orange; post-scutellum yellow, but the yellow marks on prothorax and mesothorax wanting; face much broader; scape slender and with more black; flagellum normal, but the third antennal joint is at least as long as the next three together; clypeus with more black; lateral face marks reduced to irregular triangles, not going above level of antennæ; legs without yellow, except on the anterior and middle knees; middle tibiæ and tarsi brownish with curious short glittering hair; hair on inner side of middle and hind basitarsi dark fuscous; hind tibiæ and basitarsi broad, with a large glittering scopa; hind tibial spurs slender and normal; abdomen marked as in the male, but first segment black with a transverse yellow band not quite reaching the margins; fifth segment with a heavy fringe of fuscous hair; venter black, with long white hairs fringing the segments.

*Habitat*.—Carcarana, Argentine Republic (*L. Bruner*). One of each sex. In Friese's table of *Tetrapedia*<sup>a</sup> this runs to 31, and runs out because of the coloration of the venter of abdomen. It thus falls into the *T. picta* group of Friese. Since writing the above, I have corresponded with Doctor Friese, who would place the insect (along with Holmberg's *Chacoana*) in *Epicharis*. To this I can not assent, as *Epicharis* is derived from *Tetrapedia*, mainly by the reduction in the joints of the maxillary palpi; the subgenus *Epicharoides*, which most resembles *Canonomada*, has these palpi three-jointed. *Canonomada* has six-jointed maxillary palpi, and thus goes with *Tetrapedia*. On the other hand, I must agree with Doctor Friese that *Canonomada* is the same as *Chacoana*. Holmberg's description of *Chacoana melanoxantha* appeared in 1903, and so *Canonomada* has priority. Mr. Schrottky wrote me in 1906 that he had seen a specimen of *Chacoana melanoxantha* from Asunción and ascertained that it was not an *Epicharis*.

<sup>a</sup> Ann. k. k. Naturhist. Hofmuseums, Wien, 1899, p. 278.

## Genus EMPHOROPSIS Ashmead.

EMPHOROPSIS MURIHIRTAE MURINA (Ashmead MS.), new subspecies.

*Meliturgopsis* ASHMEAD, Trans. Amer. Ent. Soc., XXVI, 1899, p. 62.—COCKERELL, Ann. Mag. Nat. Hist., Jan., 1901, p. 49. (No species cited in either place.)

*Male*.—In all respects like *E. murihirta* Cockerell, except that the face markings are ivory white instead of yellowish; the hair of the thorax is mouse-grey mixed with black, without the yellow tint; and the abdomen beyond the first segment is rather densely beset with long pale hair, not mixed with black.

*Habitat*.—San Francisco County, California, October (collector unknown). Typical *E. murihirta* is from Los Angeles. It has in the male much black hair on the second and following abdominal segments, and a silvery-white fringe just before the apex.

*Type*.—Cat. No. 12237, U.S.N.M.

A male specimen without locality, labeled as representing another species of *Meliturgopsis*, is *Anthophora pacifica* Cresson. This insect is much like the male of *A. porterae* Cockerell, but among other characters the labrum is longer and conspicuously turned up at the end. It occurs in California.

## EMPHOROPSIS VIERECKI, new species.

*Emphoropsis*, new species, COCKERELL, Canadian Entomologist, July, 1905, p. 265.

Allied to *E. pascoensis* Cockerell, but hair of face and vertex without black intermixed. Colorado and New Mexico. I supposed in 1905 that Mr. Viereck was about to describe it, but as he did not do so, I provide a name.

The type is in the collection of the American Entomological Society.

## ALLODAPE PHILIPPINENSIS (Ashmead).

*Prosopis philippinensis* ASHMEAD, Journ. N. Y. Ent. Soc., XII, 1904, p. 5.

*Allodape philippinensis* ASHMEAD, Proc. U. S. Nat. Mus., XXVIII, 1904, p. 149.

Although Doctor Ashmead corrected the generic reference in his list, he did not indicate that the species was previously described under *Prosopis*. The original description included a note stating that the reference to *Prosopis* was provisional, and not really correct. I have examined the type, an interesting little species, best distinguished by the fact that the hind margins of the abdominal segments are very narrowly testaceous. The description almost exactly agrees with that given by Bingham for *Allodape marginata* Smith, an insect only known by the unique type in the British Museum, reputed with doubt to be from the East Indies. I suspect that *A. marginata* really came from the Philippines, and is the same as *A. philippinensis*.

## COELIOXYS MANILÆ (Ashmead).

*Coelioxys manila* ASHMEAD, Canad. Entomologist, XXXVI, p. 281.

The last dorsal segment (female) is broadly rounded, much like that of *C. lanceolata* Nylander.

## MEGACHILE ROBBII (Ashmead).

*Megachile robbii* ASHMEAD, Proc. U. S. Nat. Mus., XXVIII, p. 128. (Female.)

The ventral scopa is very pale fulvous, black at tip; the tegulae are red with a black basal spot. The unique type is from Manila.

## Genus MESOTRICHIA Westwood.

This genus, usually considered a synonym of *Xylocopa*, appears to be valid, as Ashmead states.<sup>a</sup> I can not satisfactorily separate *Cyaneoderes* from it.

## MESOTRICHIA CÆRULEA (Fabricius).

*Bombus cæruleus* FABRICIUS, Syst. Piez., 1804, p. 345. ("New Caledonia.")  
*Xylocopa semiarmenia* LATREILLE; WIEDEMAN, Mag. f. Ent., IV (1821),  
 p. 421.—LEPELETIER, Hist. Nat. Ins. Hym., II, 1841, p. 200, as synonym.  
 (Java.)

*Xylocopa carulea* LEPELETIER, Hist. Nat. Ins. Hym., II, 1841, p. 200.—FRIESE,  
 Abt. Nat. Ver. Bremen, 1904, p. 134. (Buitenzorg, Java.)

*Koptorthosoma caruleum* CAMERON, Proc. Zool. Soc., London, May, 1901,  
 p. 34. (Malay Peninsula.)

*Cyaneoderes fairchildi* ASHMEAD, Trans. Amer. Ent. Soc., XXVI, 1899,  
 p. 70. (Java; the specimens collected by D. G. Fairchild at Buitenzorg, 1896.)

## MESOTRICHIA ABBOTTI, new species.

Differing from *M. carulea* as follows:

*M. carulea* (female).

Larger; anterior wing 19–20 mm. long.

Only two submarginal cells, the first transverso-cubital nervure absent, or represented by a faint streak.

First abdominal segment quite densely clothed with blue hair; sides of second fringed with blue.

Wings fuscous, with pinkish-purple iridescence.

Supraclypeal ridge prominent and shining.

*M. abbotti* (female).

Smaller; anterior wing not over 16 mm. long.

Three complete submarginal cells, the first transverso-cubital nervure strong.

First abdominal sparsely and inconspicuously clothed with blue hair; sides of second without blue.

Wings darker, the purple stronger.

Supraclypeal ridge less prominent.

*Habitat*.—Trong, Lower Siam (Dr. W. L. Abbott). Three females. Also from Trong, collected by Doctor Abbott, is a female of genuine *M. carulea*, with the face narrower than the average of the Javan specimens, but evidently conspecific with them. I accept as the genu-

<sup>a</sup> Trans. Am. Ent. Soc., XXVI, p. 71.



ine *M. carulea* the insect described by Lepeletier, who particularly calls attention to the peculiarity in the venation. The *Xylocopa carulea* of Bingham,<sup>a</sup> is *M. abbotti*, as his figure very clearly shows.

Fabricius described his *Bombus caruleus* from New Caledonia, and Bingham says that it ranges to New Caledonia. Vachal has recently reported on a collection of bees from New Caledonia, and includes neither *M. carulea* nor any relative of it. I think there can be no doubt that "New Caledonia" was an error, the real range of the insect being from Java to Siam. Another blue-haired species, *Xylocopa grubaueri* Friese, has been described Upper Perak, Malacca. It is very distinct from those now under discussion.

The male of *M. carulea* was briefly indicated by Ashmead from the Javan specimens under his generic description of *Cyaneoderes*. It is large, black, with the hair of the head and thorax (so far as can be seen from the specimens, which have been in spirit) greenish or olivaceous brown, not at all blue. The eyes are very large, and approach above, leaving only a narrow space between them and the large ocelli. The face is without light markings; the copper-red hairs on the labrum are very brilliant. The wings are a little lighter than in the female. The abdominal segments are red at the extreme base, as becomes conspicuous when they are unusually extended. The hind tibiæ have at the apex within a large obtuse shining tubercle, the end of which is directed posteriorly. The flagellum beyond the base is ferruginous beneath.

*Type*.—Cat. No. 12238, U.S.N.M.

#### Genus PERDITOMORPHA Ashmead.

*Perditomorpha* ASHMEAD, TRANS. AMER. ENT. SOC., XXVI, 1899, p. 86.

This is a genus of Panurgines close to *Camptopæum*, from which it is distinguished by the absence of light markings on the face, the simple spur of middle tibia, the very narrowly subtruncate marginal cell, and the transversomedial nervure meeting the basal. These remarks all apply to the female, the male of *Perditomorpha* being unknown. In the type of *Camptopæum* (*C. frontale* Fabricius from Europe) the basal nervure falls far short of the transversomedial, and the second submarginal cell is longer than the first. In the South American *C. ochraceum* Friese, *C. submetallicum* Spinola, and *C. flaviventris* Friese, which are before me, the basal nervure also falls far short of the transversomedial, and the apex of the marginal cell is much more remote from the costa than it is in *Perditomorpha*. The spur of the middle tibia is finely denticulate in all these species, as also in *Parafriesea*<sup>b</sup> *prinii* (*P. brasiliensis* Schrottky, *Camptopæum prinii* Holmberg).

<sup>a</sup> Fauna of British India, Hymenoptera, I, p. 544, pl. iv, fig. 8.

<sup>b</sup> Friese refers this genus to *Perdita*. It is very distinct from *Perdita*, but scarcely separable from *Calliopsis*.



In *Acamptopæum*<sup>a</sup> the body is somewhat hairy, the basal nervure meets the transversomedial, and the second submarginal cell is scarcely longer than the first. In all this there is close approximation to *Perditomorpha*, but in other respects the bees are not very similar.

In *Spinoliella* (*S. zebrata* Cresson, *S. obscurella* Cresson) the venation is essentially as in *Acamptopæum*, and the middle tibial spur (female) is very finely denticulate.

In *Psanythia* (*P. philanthoides* Gerstaecker, *P. annulata* Gerstaecker) the middle tibial spur is strongly obliquely dentate; the basal nervure almost meets the transversomedial in *P. philanthoides*, but falls some distance short of it in *P. annulata*.

In *Hypomacrotera* the end of the marginal cell is as in *Perditomorpha*, but the basal nervure falls short of the transversomedial.

In *Greeleyella* the basal nervure meets the transversomedial, but the end of the marginal cell is not at all as in *Perditomorpha*, and the first recurrent nervure meets the first transversocubital.

In *Hesperapis* the shape of the third discoidal cell and the end of the marginal are very different from those in *Perditomorpha*.

*Parandrena* is easily known from *Perditomorpha* by the broad foveæ, which are as in *Andrena*.

All things considered, *Perditomorpha* is nearest to *Acamptopæum*, but apparently sufficiently distinct. Should they be merged, Ashmead's genus has priority.

In regard to the mouth parts *Perditomorpha* runs in the table in *Annals and Magazine of Natural History*, July, 1902, p. 42, to *Hesperapis*, to which it is not closely allied.

#### PERDITOMORPHA BRUNERII Ashmead.

*Female*.—Length 9–10 mm.; *Andrena*-like in appearance; black, with a shining ferruginous-red abdomen; pubescence rather short, white, fuscous at apex of abdomen, a few infuscated hairs on scutellum, more or less fuscous on middle tibiæ in front, and coarse and strongly fuscous on upper outer side of hind tibiæ. The white hair of the face, cheeks, pleura, and sides of metathorax is abundant and conspicuous. Head broad, facial quadrangle about square, the inner orbits practically parallel; clypeus shining, densely punctured, with a median raised line; no Andreniform facial foveæ; front closely punctured; sides of vertex shining, with a considerable impunctate area; ocelli rather large, in an extremely low triangle; antennæ very short, scape black, flagellum black basally and suffused with black above, but otherwise deep chestnut-red; second antennal joint rather large; third much longer than fourth, the latter being broader than long; labrum

<sup>a</sup> Cockerell, Trans. Am. Ent. Soc., XXXI, 1905, p. 320.

ordinary, not notched; mandibles with strong inner tooth; labial palpi short, four-jointed, the first joint conspicuously shorter than the other three combined (its length about  $145\ \mu$ ), and the whole palpus hardly  $340\ \mu$  long; mentum long, about  $1,530\ \mu$ , its breadth near apex about  $290\ \mu$ ; maxillary palpi short and rather thick, six-jointed, much shorter than blade of maxilla, though considerably more than half its length, the joints measuring in  $\mu$ : (1) 135, (2) 69, (3) 50, (4) 42, (5) 35, (6) 60; the ends of the fourth and fifth joints are very oblique; maxillary blade narrow, obtusely pointed, about  $600\ \mu$  long, with subapical bristles; maxillary comb well developed, but the teeth rather short and blunt; maxillary stipes about  $1,275\ \mu$  long, with plumose hairs at the base.<sup>a</sup> By some accident the tongue was lost in the single preparation I was able to make.

Thorax robust, shining; the scutellum moderately convex, very sparsely punctured, but the hind margin delicately fluted; mesothorax rather sparsely but strongly punctured, with distinct median and parapsidal grooves; postscutellum very hairy, as also the metathorax, except the large triangular nude basal area, which is smooth and shining, without sculpture; legs ordinary, the hind legs, and also the ventral hairs of the abdomen, carrying much yellow pollen; claws cleft; pulvillus large; spurs simple; tegulae dark brown; wings dusky hyaline, distinctly reddish, nervures and stigma ferruginous; stigma large; marginal cell narrowly subtruncate, appendiculate; two submarginal cells, the second at least as long as the first below, narrowed a little more than half to marginal above, receiving both recurrent nervures, the first fully twice as far from its base as the second from its end; transversomedial nervure very oblique; abdomen dull, the broad hind margins of the segments more shiny, and pale golden-hyaline; segments two to four very sparsely fringed with white hairs, not enough to form bands; venter very hairy.

*Habitat*.—Carcarana, Argentine Republic (*L. Bruner*). Two females, one being Ashmead's type.

NOMIA (CROCISASPIDIA) CHANDLERI (Ashmead).

*Crocisaspidia chandleri* ASHMEAD, Trans. Amer. Ent. Soc., XXVI, 1899, p. 68.

*Female*.—Length about 14 mm., robust, dull black, the first four abdominal segments with broad marginal bands, of which the middle third is lacking, of a most brilliant turquoise blue; face, prothorax, pleura, and sides of metathorax with much white hair; sides of mesothorax posteriorly, and basin of postscutellum covered with

<sup>a</sup>In *Hesperapis* (*H. rhodocrata* Cockerell) the maxillary palpi are really very different, in that the first joint is much shorter than the second, and the joints are more narrowed basally. The stipes is also very much shorter in proportion. The maxillary palpi of *Perditomorpha* are nearly the same as those of *Hypomacrotera* (Cockerell and Porter, Ann. Mag. Nat. Hist., Dec., 1899, p. 419), but the labial palpi are very different.

dense white tomentum; scutellum with lateral lobes, and postscutellum produced, exactly as in *N. scutellaris* Saussure, from Madagascar; antennæ black, the flagellum stout, greyish-pruinose; mesothorax with dense but rather shallow punctures; scutellum very densely punctured; tegulæ large; anterior wings fuscous-black, with violaceous tints; posterior wings hyaline; legs black, the coarse scopa of hind legs black; anterior and middle tibiæ each with a large patch of white hair on outer side, occupying all but apical part of anterior, but little more than basal half of middle ones; some white hair also behind the hind knees.

*Habitat*.—Jombene Range, East Africa (Chanler-Hohnel Expedition). The specific name should apparently have been *chanleri*, not *chandleri*. The above description disagrees in some important particulars with Ashmead's brief account, and the type specimen bears a specific name dedicating the insect to Doctor Abbott. It is, however, the true (and unique) type, as Doctor Ashmead showed it to me when I was in Washington some years ago, remarking that he had labeled it under the impression that it was caught by Doctor Abbott, and would have to change the name. The name *Crocisaspidia* may very well be used in a subgeneric sense, for the species of the group of *Nomia scutellaris*, namely:

(1) *N. scutellaris* Saussure. Madagascar. With entire white bands; wings not very dark.

(2) *N. maculata* (Friese). Grotfontein, Southwest Africa; Langenburg, Lake Nyassa. Abdominal segments one to four with bluish-white spots on each side; scopa white.

(3) *N. nigripes* (Friese). Ondonga, Southwest Africa; Old Calabar, West Africa; Chinchoxa, Africa; Togo, Africa. Much like *maculata*, but scopa black, etc.

(4) *N. amabilis* Cockerell. Benguella. Similar in most respects to *chandleri*, but postscutellum without white tomentum, and its lobes much more pointed; while the abdominal markings are of quite a different tint, a clear blue with purplish shading, whereas in *chandleri*, they are of a deeper and greenish-blue by comparison.

(5) *N. chandleri* [*chanleri*] (Ashmead).

#### NOMIA (HOPLONOMIA) QUADRIFASCIATA (Ashmead).

*Hoplonomia quadrifasciata* ASHMEAD, Journ. N. Y. Ent. Soc., XII, p. 4.

I have examined the type; the abdominal bands are green, tinged with orange-vermilion.

#### HALICTUS PHILIPPINENSIS Ashmead.

*Halictus philippinensis* ASHMEAD, Proc. U. S. Nat. Mus., XXVIII, p. 128.

A species with the general aspect of *H. pectoralis*; the hind spur of hind tibiæ long pectinate; third submarginal cell of the short type; hair of abdomen at lateral bases of segments one and two, and across on three and four.



## HALICTUS MANILÆ Ashmead.

*Halictus manilæ* ASHMEAD, Canadian Entomologist, XXXVI, p. 281.

A very ordinary looking species, with basal hair-bands on abdomen; hind spur of hind tibia pectinate with four teeth, two long; third submarginal cell short.

## Genus MICRANDRENA Ashmead.

The group which Robertson<sup>a</sup> calls *Opandrena* is readily divisible into two very distinct series, which seem to deserve subgeneric rank under *Andrena*. These are as follows:

Abdomen evidently punctured; basal nervure practically meeting transversomedial; apex of marginal cell rounded, not on costa; end of first transversocubital nervure not close to stigma.

*Opandrena* Robertson (type, *cressonii* Robertson)

Abdomen impunctate or practically so; basal nervure falling some distance short of transversomedial; apex of marginal cell more pointed, and on costa; end of first transversocubital nervure very near to the large stigma.

*Micrandrena* Ashmead (type, *pacifica* Ashmead)

*Micrandrena* also includes *Andrena ziziæ* Robertson, *A. personata* Robertson, and *A. fragariana* Graenicher. Unfortunately there is another type of *Andrena*, that of *A. flavoclypeata* Smith, which though placed by Robertson in *Opandrena*, does not fit into either of the groups defined above. It is near to *Micrandrena*, but the basal nervure almost meets the transversomedial, falling only a little short of it, and the end of the first transversocubital is not close to the stigma. *A. flavoclypeata* is larger than *Micrandrena*, but *A. ziziæformis* Cockerell, from Virginia, falls with it according to the characters cited, and yet has the stature and appearance of a *Micrandrena*.

Those who accept the whole series as one, following Robertson, must use Ashmead's name *Micrandrena*, which was published in 1899, while *Opandrena* was not published until 1902. In Ashmead's description of *Micrandrena* it appears that the facial foveæ are wanting; this is not really the case, they are quite distinct and practically as in *A. ziziæ*, of a seal-brown color, appearing white in certain lights.

## ANDRENA PACIFICA (Ashmead).

*Micrandrena pacifica* ASHMEAD, Trans. Amer. Ent. Soc., XXVI, 1899, p. 89 (no locality cited).—COCKERELL, Psyche, X, 1903, p. 75 (California).

*Female*.—Stature and appearance as in *A. ziziæ* Robertson; differing from *ziziæ* as follows: Anterior middle of clypeus very shiny, with sparse punctures; flagellum dark, not ferruginous beneath; area of metathorax rougher; wings yellowish, nervures clear ferruginous, second submarginal cell broader; apical depression of second abdominal segment stronger and a little larger.

*Habitat*.—Alameda County, California. June (collector not stated on label.)

<sup>a</sup>Trans. Amer. Ent. Soc., XXVIII, p. 193.



## DESCRIPTION OF A NEW ISOPOD OF THE GENUS *JÆROPSIS* FROM PATAGONIA.

By HARRIET RICHARDSON,

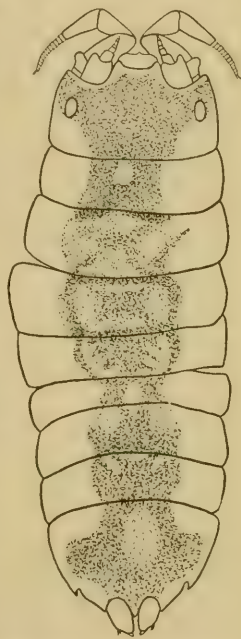
Collaborator, Division of Marine Invertebrates, U. S. National Museum.

A species of *Jæropsis*, heretofore undescribed, was collected by the U. S. Bureau of Fisheries steamer *Albatross* during its cruise off the east coast of Patagonia in 1888. The list of species in this genus now includes *Jæropsis brevicornis* Kœhler,<sup>a</sup> *J. marionis* Beddard,<sup>b</sup> *J. curvicornis*<sup>c</sup> (Nicolet),<sup>d</sup> *J. lobata* Richardson,<sup>e</sup> *J. dollfusi* Norman,<sup>f</sup> *J. rathbunæ*<sup>g</sup> Richardson, and the present species.

### *JÆROPSIS PATAGONIENSIS*, new species.

Body oblong-ovate, about two and two-thirds times as long as wide. The lateral parts of the thoracic segments are yellow. Most of the head and most of the abdomen as well as the middle of the dorsal region of the thorax is colored reddish brown.

The head is wider than long and has the post-lateral angles rounded, the antero-lateral angles acute. The anterior margin is produced on either side of the median line in a small triangular process. In the concavity formed between the two is placed a small lobe, the anterior margin of which is produced in the middle in a small point. The eyes are placed about halfway between the anterior and the



*JÆROPSIS PATAGONIENSIS*.  
× 14.

<sup>a</sup> Ann. Sci. Nat., (6), XIX, 1885, p. 7.

<sup>b</sup> Challenger Report, XVII, 1886, p. 20.

<sup>c</sup> Stebbing has recently shown that *Jæropsis neo-zealandica* Chilton is a synonym of *Jæropsis curvicornis* (Nicolet). Ceylon Pearl Oyster Fisheries Report, Pt. 4, 1905, p. 51.

<sup>d</sup> Historia de Chile, III, 1849, p. 263, pl. 3, fig. 10.

<sup>e</sup> Proc. U. S. Nat. Mus., XXI, 1899, p. 857.

<sup>f</sup> Ann. Mag. Nat. Hist., (7), IV, 1899, p. 291, pl. 5, figs. 2-8.

<sup>g</sup> Trans. Conn. Acad. Sci., XI, 1902, p. 298, pl. 40, figs. 53-55.

posterior margins of the head and a distance from the lateral margin equal to the width of one eye. The first pair of antennæ have the first article large; the second is about one-half as large as the first; the third is as long as the second, but narrower; the fourth is half as long as the third; the fifth is a little longer than the fourth; the sixth and seventh are subequal and only about half as long as the fifth. The second antennæ have the first article very short; the second is about three times longer than the first; the third is quite long, about three times longer than the second; the fourth and fifth are about equal in length and each is a little shorter than the third; the flagellum is composed of twelve articles. The antennæ are geniculate at the articulation of the third and fourth articles.

The first and fourth segments of the thorax are subequal in length; the second and third are subequal and are the longest; the fifth is the shortest; the sixth and seventh are subequal and are a little longer than the fourth but not quite as long as the third. The sides of the segments are almost straight and the epimera are not indicated.

The abdomen consists of a single segment. The posterior margin is deeply excavate on either side of an acute median point. The post-lateral angles are also acute. About one-third the distance from the post-lateral angles the sides of the abdomen are produced in a small, but pronounced tooth, just above a small excavation in the lateral margin. The uropoda are placed in the posterior excavations of the posterior margin, and consist of a large peduncle, about twice as long as wide, and a minute inner branch, tooth-like, and an outer branch, which in a dorsal view is apparent only as a bunch of hairs. In a ventral view the outer branch is placed in an excavation, is minute, and does not reach beyond the posterior margin of the peduncle.

The legs are all similar and terminate in biunguiculate dactyli.

Three specimens, all females, come from U. S. Bureau of Fisheries station 2770, east coast of Patagonia. They were collected by the steamer *Albatross* at a depth of 58 fathoms in gray sand and black specks.

*Type*.—Cat. No. 39240, U.S.N.M.

## AMMODISCOIDES, A NEW GENUS OF ARENACEOUS FORAMINIFERA.

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By JOSEPH A. CUSHMAN,  
*Of the Boston Society of Natural History.*

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While examining the original material upon which Dr. Axel Goës based his paper on the Foraminifera of the expedition to the Galapagos Islands, a few species included in that report from the Gulf of Mexico were studied. Among these, certain specimens were found under the name of *Ammodiscus incertus* d'Orbigny, which were at once seen to be peculiar. Instead of the ordinary plano-spiral test of that species these specimens were found to be really conical, especially the young, the first few revolutions forming a hollow cone. This portion stands out as a large prominence in the younger specimens, especially when seen in the view shown in fig. 3. An illustration of this young alone is shown in fig. 4. In later growth the revolutions form a low, flaring cone in the reverse direction. This character may be best seen in the diagrammatic sections, figs. 5 and 6. In occasional specimens, instead of reversing the direction, the cone developed in the young simply becomes more flaring. The specimens were all from the Gulf of Mexico, from Albatross Station 2383, from 1,181 fathoms. In all there were eighteen specimens of varying size. The specimens from the Pacific in the Goës collection were all of the typical *Ammodiscus tenuis* or *A. incertus* forms, all plano-spiral throughout their development.

In the early development of the conical species there is a certain resemblance to *Gordiaminna* and *Turritella*, but the later portion is very different. Each of the eighteen specimens had a microspheric proloculum, or initial chamber. The early coils are very uniform in size, and in this respect are again like the other two genera to which reference has already been made. In texture the specimens are much

like the ordinary *Ammodiscus*, but the color is a peculiar, dark reddish brown. A description of the genus and species follows:

Genus AMMODISCOIDES, new.

Test free, spiral, consisting of an initial chamber followed by a nonseptate tube, the early portion forming a hollow cone; later portions becoming usually conical in the opposite direction from that of the younger portion, wall finely arenaceous, smooth.

This genus is split off from *Ammodiscus* which is planospiral both in the young and later development, while the genus *Ammodiscoides* has a definite conical young and broadly flaring later development.

*Type of the genus.*—*Ammodiscoides turbinatus*.

AMMODISCOIDES TURBINATUS, new.

Test of fine sand grains with a chitinous cement, surface smooth, of a dark reddish brown color, revolving edge flattened, making the aperture low and broad, quadrangular, entire test consisting of as many as thirty coils, those of the early conical portion of nearly uniform diameter, the later ones gradually increasing in height and width.

Maximum diameter of fully developed specimens, 3 mm.

*Type.*—Cat. No. 7717, U.S.N.M., from *Albatross* station 2383, 1,181 fathoms, in the Gulf of Mexico.

EXPLANATION OF PLATE 33.

FIG. 1. Complete specimen  $\times 20$ .

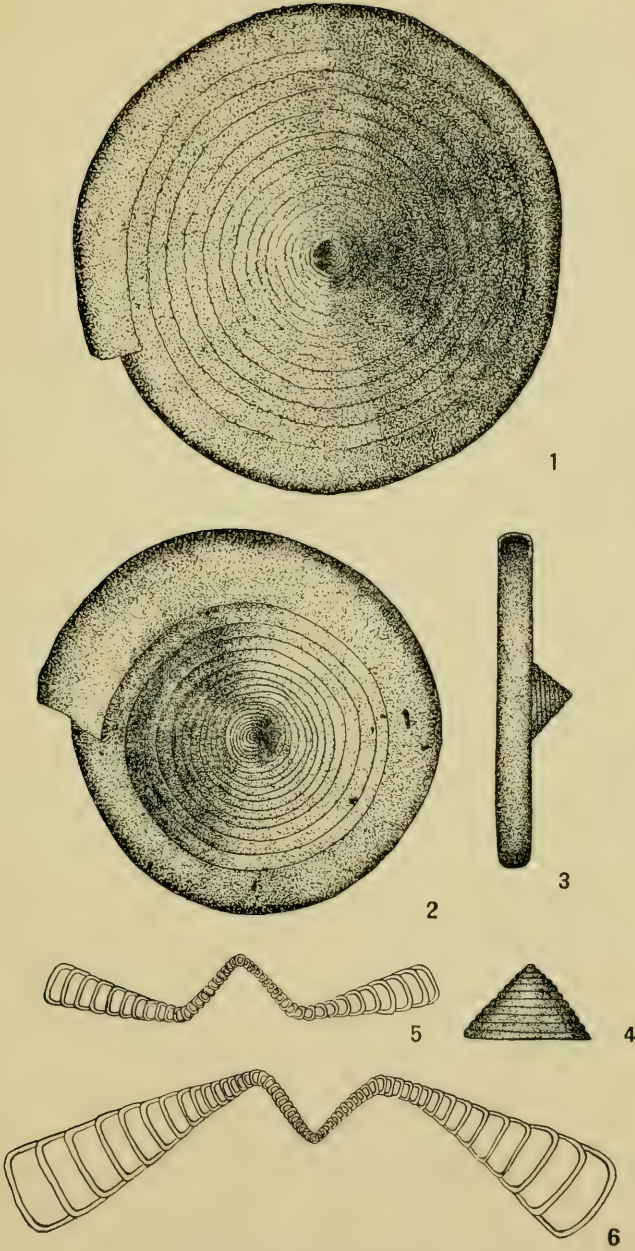
2. Younger specimen  $\times 45$ .

3. Apertural view of a still younger specimen showing the conical young  $\times 60$ .

4. The young portion of the test without the later coils  $\times 75$ .

5, 6. Diagrammatic sections showing the reversing of the conical form in the later coils  $\times 45 \times 60$ .





A NEW GENUS OF ARENACEOUS FORAMINIFERA.

FOR EXPLANATION OF PLATE SEE PAGE 424.



## DESCRIPTION OF A NEW WHITEFISH (COREGONUS OREGONIUS) FROM MCKENZIE RIVER, OREGON.

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By DAVID STARR JORDAN and JOHN OTTERBEIN SNYDER,  
*Of Stanford University, California.*

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In this paper the description of a new species of whitefish from McKenzie River, in Oregon, is presented.

COREGONUS OREGONIUS Jordan, and Snyder, new species.

### CHISEL-MOUTH JACK.

*Coregonus williamsoni* JORDAN and EVERMANN, Fish. North Middle Amer., I, p. 463, 1898, in part, not of Girard.

Head 4 in length to base of caudal fin; depth 5; depth of caudal peduncle 15; eye  $5\frac{1}{2}$  in head; snout  $2\frac{1}{3}$ ; interorbital space 4; scales in lateral series 86; between lateral line and base of dorsal 9; between lateral line and base of anal 6; dorsal rays 12; anal rays 12.

Body long and slender, the caudal peduncle narrow; snout very long, the end fleshy, rounded and somewhat turned up; interorbital space broad and convex. Maxillary 4 in head,  $2\frac{2}{3}$  when measured from tip of snout, its width equal to two-thirds of its length; the upper edge almost straight, the lower broadly and rather evenly curved. Lower jaw much shorter than the upper, the square anterior edge fitting beneath the overhanging upper lip; lateral edge of lower lip thin, broad, and pendent. Branchiostegals 8, broad and leaf-like. Gillrakers 6+13, short, pointed, and comparatively slender. Eye located nearer tip of snout than edge of opercle by a distance equal to half its diameter; a narrow, thin, adipose lid anteriorly. Openings of nostril separated by a valve-like partition. A row of prominent mucous tubes extending along the suborbital bones, below and behind the eye.

Scales moderate; 32 tranverse rows between occiput and origin of dorsal; small scales along basal part of adipose dorsal, there being 5 or 6 rows a short distance behind its origin; a large scale above axil of ventral, the length of which is contained  $2\frac{1}{4}$  times in the length of fin. Lateral line almost perfectly straight.

Origin of dorsal nearer tip of snout than base of caudal by a distance equal to length of maxillary; edge of fin concave; first ray highest, the length contained  $1\frac{1}{5}$  times in head. Adipose fin of enormous size, the length of its base equal to that of anal fin; the height contained  $2\frac{1}{2}$  times in the length of its base. Anal inserted opposite the adipose fin, the posterior ends of their bases being on the same vertical line; height of longest (first) ray contained  $1\frac{3}{5}$  times in the head. Pectoral sharply pointed, the length contained  $1\frac{3}{5}$  times in the head. Origin of ventrals below middle of dorsal, their length equal to highest dorsal ray. Caudal deeply notched, the lobes rounded  $1\frac{1}{3}$  in head.

Color silvery, somewhat dusky above; edges of fins dusky.

Described from the type, Cat. No. 62987, U.S.N.M., a female specimen 480 mm. long, the largest specimen known, from the McKenzie River, Oregon, collected by Mr. A. C. Bassett, of Menlo Park, California. Many others, including the cotypes, Cat. No. 21140, Stanford University collection, were sent by H. C. MacAllister, head fish warden of the State of Oregon. The figure of the type, a female as above indicated, is drawn by Mr. William S. Atkinson.

Females ready to spawn, others with the eggs considerably smaller, and males with the reproductive organs greatly developed, are at hand. A male specimen has the body covered with tubercles, one on each scale. The snout appears to increase in length and become prominent with age. Its great length is not a character peculiar to either sex, nor is it an indication of sexual maturity. Small individuals (measuring about 250 mm.), both males and females, sexually mature, have relatively short snouts. The adipose dorsal is relatively larger in older specimens, but even in very small examples its base is nearly equal to that of the anal fin, and it is much higher than any other whitefish. The young of this species have large dark spots on the upper surface, and a series of short, broad, vertical bars along the lateral line.

The following is a table of proportional measurements:

Length (to base of caudal) in millimeters--	425	384	340	248	226
Length head, in hundredths of length-----	.25	.245	.225	.225	.215
Depth caudal peduncle-----	.062	.06	.062	.052	.056
Length snout-----	.095	.08	.075	.074	.062
Tip of snout to end of maxillary-----	.085	.08	.072	.07	.06
Snout to occiput-----	.19	.195	.175	.17	.165
Length base adipose fin-----	.13	.12	.12	.115	.105
Height of adipose fin-----	.06	.045	.055	.05	.055
Dorsal rays-----	12	13	13	13	12
Anal rays-----	12	12	12	12	11
Scales in the lateral line-----	86	81	85	85	84

For several summers Mr. A. C. Bassett, of Menlo Park, California, has visited the McKenzie River, in central Oregon, and has reported



the presence of a remarkable game fish there, which is locally known as the "Chisel-mouth Jack." The present writers supposed this to be the Chisel-mouth Chub, *Acracheilus alutaceus*. At our suggestion, however, Mr. Bassett brought home a fine specimen of the game fish, and it proves to belong to the group of *Coregoninae* or white fishes. The species reaches a length of about 18 inches, is extremely swift and gamey, takes the hook readily, and is reputed to be very destructive to the spawn of salmon. After the receipt of the original specimen from Mr. Bassett we secured numerous others, also from the McKenzie River, through the courtesy of Mr. H. C. MacAllister, master fish warden of the State of Oregon. Numerous young examples were found in the collection of Stanford University, from Weiser River, at Weiser, Idaho (Coll. J. O. Snyder), and Payette River, at Payette, in Idaho (Coll. C. H. Gilbert No. 2127, Stanford University), and from Willamette River at Corvallis, Oregon (Coll. J. O. Snyder).

From a letter of Mr. Bassett dated September 15, 1908, we quote the following:

I have never looked to ascertain the contents of the stomach of the "Chisel-mouth Jack," but as the fish rises to natural and artificial flies, I presume they take about the same feed as the trout. They feed at the same time and at the same places as the Rainbow and Cut-throat Trout, and take the same artificial flies.

The river from which this fish was taken, the McKenzie, heads near the Three Sisters in Lane County, Oregon, and is the outflow from a small snow-fed lake, about 100 miles northeast of its junction with the Willamette River at Coburg. It is in the main a rapid-flowing river, but with stretches of an eighth or quarter of a mile of quieter water, well shaded with willow, cottonwoods, maples, cedars, and pines; width from 150 to 300 feet, depth 3 to 6 feet, and much deeper in the pools; cold and clear water carries besides this the Dolly Varden, Rainbow, Cut-throat Trout, Suckers, and a Lamprey.

The "Chisel-mouth Jack" or "Chisel Bill," as they are often called locally, are quite plentiful, and are persistent in rising to the natural or artificial fly, and will often strike eight or more times if not successful sooner in taking the lure. They make about the same struggle to escape that a Rainbow does. My largest capture weighed 2½ pounds, but old residents told me they had taken them weighing 4 pounds, and I think this statement can be relied on. They are a good table fish, preferred by many to the trout. The flesh when cooked is a light pink, about the same as the trout in color, but of a distinct flavor.

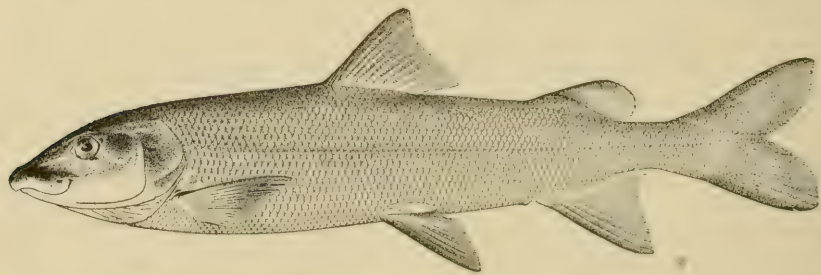
The fish when first taken shows yellowish brown above median line and white below. I presume they spawn in the small streams emptying into the McKenzie, a great number of which furnish good spawning grounds for fish, as they are brushy, cold-water, continuous flowing streams. The specimen you have was taken near Deerhorn post-office, about 30 miles up the river from Coburg.

Eugene City is the nearest point by rail to reach the McKenzie, stages running from there to Belknap and Foley Springs, 60 miles distant.

The river carries an abundance of feed, and eleven years ago, when I first visited it, was full of fine, fat, lively trout. Constant fishing by numbers of anglers from abroad, and by the loggers engaged in driving logs to the mills

near Eugene, has greatly diminished the day's catch, but the anglers at Eugene and vicinity are now fully alive to the situation, and propose to restock it. It is a beautiful stream, even grand in some of its stretches, and all along 70 of its miles of flowing through a fine canyon, a sight to delight the eyes of an angler.

The species is related to the Rocky Mountain whitefish, *Coregonus williamsoni* Girard, with which it has been hitherto confounded. From this species it differs mainly in the slender body, slenderer caudal peduncle, produced and pig-like nose, and especially in the extremely high "banner-like" adipose fin, which in old and young is far larger than in any other Salmonidae. The description of *Coregonus williamsoni* given by Jordan and Everman<sup>a</sup> is drawn mainly from the Chisel-mouth Jack. The fish wardens of Oregon have thus far recognized but one species of whitefish in Oregon. The essential characters of this species are those of the subgenus or genus *Prosopium*, but the long nose, and especially the very large adipose fin, separate it widely from *Coregonus quadrilateralis*, the type of



COREGONUS OREGONIUS.

*Prosopium*. In the size of the adipose fin, *Coregonus williamsoni* is intermediate between *quadrilateralis* and *oregonius*, though much nearer the former. The Rocky Mountain whitefish, *Coregonus williamsoni* Girard,<sup>b</sup> is found on the Pacific slope of the Rocky Mountains in Idaho, Washington, Montana, and British Columbia, between the Rocky Mountains and the Sierra Nevadas. It is well figured by Bean<sup>c</sup> from a male specimen from the Little Spokane River.

It is a smaller fish than the Chisel-mouth Jack, deeper in body, with snout not produced, and the adipose fin, though large and long, very much smaller than in *Coregonus oregonius*.

The figure of *Coregonus williamsoni* Girard,<sup>d</sup> from the Des Chûtes River, represents the Rocky Mountain whitefish, and not the Chisel-mouth Jack. The form of the body, the form of the head, the moderate adipose fin and robust caudal peduncle all agree with the

<sup>a</sup> Fishes North and Middle America, I, p. 463.

<sup>b</sup> Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 136; Des Chûtes R. Oregon.

<sup>c</sup> Bull. U. S. Fish Commission for 1894, p. 204, pl. XXI, fig. 3.

<sup>d</sup> U. S. Pacific R. R. Survey, 1858, p. 326, pl. LXVI.

species figured by Bean, which must be the original *Coregonus williamsoni*. Mr. Bean tells me that Girard's type-specimen is no more in existence. Though we are not sure which species exists in the Des Châtes River, and perhaps both may be found there, we must assume that Girard's figure is correct.

We have no specimens of *Coregonus williamsoni* from the Columbia Basin, for direct comparison with *Coregonus oregonus*. Examples from Sicamous, on Shuswap Lake, British Columbia (Coll. C. H. Eigenmann), and numerous fine examples from the Truckee River, California,<sup>a</sup> which may be considered as representatives of *C. williamsoni*, seem not to differ from each other, but agree closely with the figure and description published by Girard. They differ notably from *Coregonus oregonus* in the heavier body, deeper caudal peduncle, shorter and less pointed snout, and in having a comparatively small adipose fin, its base being only about two-thirds as long as that of the anal. One poorly preserved specimen of the form called *Coregonus cismontanus*, from Beaverhead River, Montana, appears to agree very closely with the above. Both the Beaverhead and Shuswap specimens are smaller than those from the Truckee River, and neither will serve to show slight differences if any such exist. Measurements of the specimens referred to are here given.

The types of *Coregonus cismontanus*, from Horsethief Springs, Madison River, Montana, are still smaller and less satisfactory. *Coregonus couesi* Milner, from Chief Mountain Lake, the head of the Saskatchewan, is doubtless the same as *Coregonus cismontanus*. *Coregonus couesi* and *Coregonus cismontanus* represent at the most a subspecies of *Coregonus williamsoni*, with possibly smaller adipose fin.

*Fin rays and measurements of Coregonus williamsoni.*

Locality.	Dorsal rays.	Anal rays.	Scales, lateral line.	Scales, transverse series.	Scales before dorsal.
Truckee River.....	13	11	82	9 + 9	32
	12	11	84	8 + 9	31
Beaverhead River, Montana.....	13	11	85	8 + 9	29
Shuswap Lake, British Columbia.....	13	11	81	8 + 9	30
	13	11	83	8 + 9	33

Locality.	Head in length.	Snout in head.	Depth of body.	Depth of caudal peduncle.
Truckee River.....	4.9	3.2	5	14
	4.7	3.2	5.2	15
	1.7	3.3	4.8	14
Beaverhead River, Montana.....	4.4	3.2	4.7	13
Shuswap Lake, British Columbia.....	4.3	3.8	4.8	14.3

According to our present view, the status of the whitefishes of the Pacific slope may be expressed thus: In the Columbia River are three

<sup>a</sup> These were collected near Floriston, California, by Mr. S. J. Mandeville.

species, one of which, *Coregonus oregonius* differs widely from the others, and is not known to be represented in any other basin. *Coregonus williamsoni* occurs also in streams to the northward of the Columbia, and in the Great Basin of Nevada. It is represented east of the divide in Montana by a slightly differentiated form, *Coregonus coxsi*,<sup>a</sup> of the Saskatchewan, which probably includes *Coregonus cismontanus*<sup>b</sup> of the Upper Missouri. The third species, *Coregonus coulteri* (Eigenmann, from the Upper Columbia River, Kicking Horse River at Field), of which we have specimens from Diamond Lake, Washington, is a species well-distinguished by its slender body and large scales, there being but 60 in the lateral line. Its relationships are not close to any other known species.

Farther east, this group or genus *Prosopium*, to which all these species belong, is represented by the Menominee whitefish, *Coregonus quadrilateralis*. *Prosopium* is distinguished from *Coregonus* proper by the short, few gill-rakers, the slender body, and the small, inferior mouth, above which are the large preorbitals, which Milner compared to a mask, προσώπιον.

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<sup>a</sup> Rept. U. S. Fish Commission for 1872, 1874, p. 88; Milner, Chief Mountain Lake.

<sup>b</sup> Jordan, Bull. U. S. Fish Commission, IX, 1889, p. 49, pl. ix, fig. 89; Horse-thief Creek, Montana.



## THE ISOPOD CRUSTACEAN ACANTHONISCUS SPINIGER KINAHAN REDESCRIBED.

By HARRIET RICHARDSON,

Collaborator, Division of Marine Invertebrates, U. S. National Museum.

In 1847 Adam White<sup>a</sup> gave the name *Acanthoniscus spiniger* to a new Isopod which Mr. Philip H. Gosse found in Jamaica. This form was not described at that time. Six years afterward the latter naturalist<sup>b</sup> referred in the following way to this isopod: "A curious little dark grey Oniscus, every segment of which is armed with two spines, was numerous; it has been described by my friend, Mr. Adam White of the British Museum, under the name of *Acanthoniscus spiniger*." The first description which was published of *Acanthoniscus spiniger* was that of Kinahan in 1859.<sup>c</sup> Kinahan's description is based on the original specimen in the British Museum, which was the only specimen he had seen. In 1885 Budde-Lund<sup>d</sup> placed in his family Onisei the genus *Acanthoniscus* of which he said: "Ad tribum Oniscorum sequentia genera in natura mihi ignota pertinere videntur." He had evidently not seen the specimen in the British Museum for he gives no description, and although he does not place the genus in either section I, *Armadilloidea*, or section II, *Oniscoidea*, yet he refers to it at the end of his section *Oniscoidea*. Kinahan did not place the genus in any family.

About 1877 Mr. H. G. Hubbard, the entomologist, made collections in Jamaica. Some of his collections were given to the Museum of Comparative Zoology and some came to the U. S. National Museum after his death. Among the insects was a specimen of *Acanthoniscus spiniger*, which was turned over to me last winter. The label accompanying it reads: "*Oniscus spiniger*. Jamaica." As I had not seen a specimen of this species before, and as the only description of it is that given by Kinahan, I thought it would be of interest to

<sup>a</sup> List Crust. Brit. Mus., 1847, p. 99.

<sup>b</sup> A Naturalist's Sojourn in Jamaica, 1851, p. 65.

<sup>c</sup> Proc. Dublin University, I, 1859, p. 197, pl. 19, fig. 4.

<sup>d</sup> Crust. Isop. Terrestria, 1885, p. 242.

redescribe and figure it. No general figure has ever been given, although Kinahan gave detailed drawings of the uropod and the terminal abdominal segment. It seems strange that, although this isopod is said to be numerous in Jamaica, no specimens exist, so far as I know, in any museum except the British Museum.

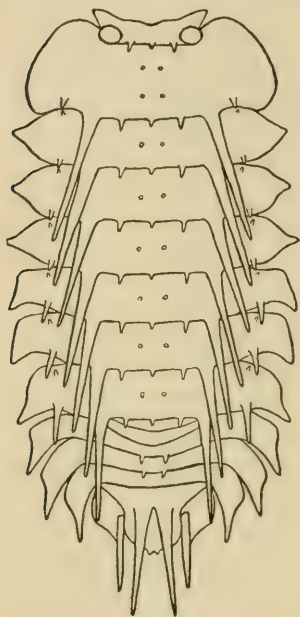


FIG. 1.—*ACANTHONISCUS SPINIGER*.

Body oblong ovate, capable of rolling up into a ball. Color, in alcohol, dark brown, with irregular spots of light brown.

Head much wider than long, with the front emarginate and the lateral angles acutely produced. The eyes are large, bulbous, composite, and situated at the post-lateral angles of the head. On the posterior margin of the head are three spines, one in the median line and one on either side, close to the eye, the median spine being smaller than the other two. The first pair of antennæ are rudimentary and inconspicuous. The second pair are broken and the flagellum lost. The first article of the peduncle is short; the second and third are long and subequal; the fourth is one and a half times longer than the third; the fifth is about one and a half times longer than the fourth.

The first segment of the thorax is longer than any of those following. The lateral parts are produced in large, rounded processes, which extend downward and upward, surrounding the posterior portion of the head. This segment is armed with two extremely long spines, one on either

### Family ARMADILLIDIDÆ.

#### *ACANTHONISCUS* Kinahan.

*Acanthoniscus* KINAHAN, Proc. Dublin University, I, 1859, p. 197.

#### *ACANTHONISCUS SPINIGER* Kinahan.

*Acanthoniscus spiniger* WHITE (*nomen nudum*), List Crust. Brit. Museum, 1847, p. 99.—GOSSE, A Naturalist's Sojourn in Jamaica, 1851, p. 65.—KINAHAN, Proc. Dublin University, I, 1859, p. 197, pl. 19, fig. 4.—BUDDELUND, Crust. Isop. Terrestria, 1885, pp. 241-242.—RICHARDSON, Bull. U. S. Nat. Mus., No. 54, 1905, pp. 637-638, 592 footnote.

Body oblong ovate, capable of rolling up into a ball. Color, in alcohol, dark



FIG. 2.—*ACANTHONISCUS SPINIGER*. SECOND ANTENNA.  $\times 23$ . (FLAGELLUM LOST.)

side, which are nearly three times the length of the segment. Between these two spines are three short ones on the posterior margin, one being in the median line. Anterior to these spines are four small tubercles, two on either side of the median line in longitudinal series. Lateral to the long spine, halfway between it and the lateral margin, is one small spine on either side. The six following segments are about equal in length. Each is armed with two extremely long spines, one on either side of the body. Between these long spines are three small spines on the posterior margin, one in the median line. Anterior to these spines are two small tubercles, one on either side of the

median line. Lateral to these spines are two small ones, halfway between them and the lateral margin, one small anterior one and a posterior one, which gradually increases in length, that on the seventh segment being about half as long as the longest spine.

The first two segments of the abdomen have the lateral parts covered by the last thoracic segment. The lateral parts of the three following segments are greatly produced, the posterior angles being acute. These five segments are about equal in length; the third and fourth are armed with two small spines on the posterior margin, one on either side of the median line. The sixth, or terminal segment, is widest at the base, contracted

about the middle with the posterior half widely rounded and notched in the middle, a small triangular process on either side of the notch. On the anterior portion of the segment are two long spines, equal in length to twice the length of the segment, placed one on either side of the median line. The peduncle of the uropoda resembles in form the lateral parts of the third, fourth and fifth thoracic segments; the inner posterior angle is acutely produced, the outer angle being rounded. The inner branch is inconspicuous in a dorsal view, being concealed beneath the abdomen; it is attached at the inner antero-lateral angle of the peduncle and does not quite reach the tip of



FIG. 3.—*ACANTHONISCUS SPINIGER*.  
UROPOD. (UNDER  
SIDE.)

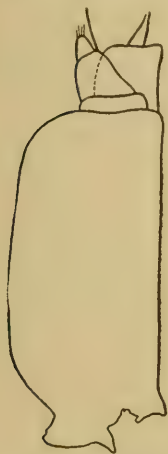


FIG. 4.—*ACANTHONISCUS SPINIGER*.  
MAXILLIPED.  
× 27½.



FIG. 5.—*ACANTHONISCUS SPINIGER*.  
SECOND MAXILLA.  
× 77½.

the abdomen. The outer branch is produced in a long spine, extending half its length beyond the inner posterior angle of the peduncle; in a dorsal view it is inserted on the inner lateral margin at the anterior angle.

An anterior view of the head shows the labrum produced on either side so as to extend much beyond the epistome. The inner lamella of the first maxillæ carries two plumose processes.

Although this specimen does not agree in every respect with the description of Kinahan, I can not but think it is the same species. Kinahan does not mention the small spines placed between the two long spines on the posterior margin of the thoracic segments. He also does not mention the



FIG. 6.—ACANTHONISCUS SPINIGER.  
FIRST MAXILLA. a. INNER LOBE.  
b. OUTER LOBE.  $\times 77\frac{1}{2}$ .

presence of spines on the abdomen, but in his figure of the terminal abdominal segment I think he intended to represent them in the two long lines in the center of his figure. His representation of the uropod does not agree with the specimen I have, but the shape of the terminal abdominal segment is so similar that I am inclined to think that there must be some error in the figure of the uropod.<sup>a</sup>



FIG. 7.—ACANTHONISCUS SPINIGER.  
ANTERIOR VIEW OF  
HEAD SHOWING  
EPISTOME WITH  
LABRUM.

<sup>a</sup> Since preparing the above description I sent a copy of my figure to Doctor Calman of the British Museum for comparison with the type. In his answer, just received, he says that he is almost certain that my specimen is *Acanthoniscus spiniger*. He mentions the fact that in the type-specimen there are two teeth instead of three on the posterior margin of the thoracic segments after the first. On the first segment, the middle tooth is extremely small. On the hinder edge of the head are only two teeth, placed a little in front of, not on, the margin. He also noticed a difference in the shape of the uropod, but thinks this may be due to its being in a slightly different position from my sketch. He very kindly made drawings of the type for me. Although I am aware of these discrepancies, I hesitate to consider my specimen other than *Acanthoniscus spiniger* when the resemblance is so strong and the locality the same. Moreover the type-specimen is probably a dried specimen and some allowance must be made for change in contour owing to its condition. When Kinahan described it, twelve years after it was collected, it was probably in no better condition than it is now.



# ADDITIONS TO THE LIST OF PHILIPPINE BIRDS, WITH DESCRIPTIONS OF NEW AND RARE SPECIES.

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By EDGAR ALEXANDER MEARNs,  
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This is the seventh of a series of papers on Philippine birds, published by the writer, adding, in all, 56 species to the list of those previously known from the islands.<sup>a</sup> It is the writer's intention soon to publish a list of Dr. Paul Bartsch's Philippine collection of birds, in which two additional forms will be described.

The following are additions to the species recorded from the Philippine Islands:

STERNA LONGIPENNIS Nordmann.

NORDMANN'S TERN.

I collected five specimens (Nos. 14065-69, author's collection) of this species, in Basilan Strait, off Zamboanga, Mindanao, April 19, 1906. Four were preserved as skins (Cat. Nos. 200770-73, U.S.N.M.) and one in alcohol.

LOBIPES LOBATUS (Linnæus).

NORTHERN PHALAROPE.

On several occasions I had seen flocks of phalaropes on the seas surrounding the Philippine Islands; and on April 19, 1906, three specimens were collected in Basilan Strait, which connects the Sulu and Celebes seas. These are Cat. Nos. 200774-6, U.S.N.M.

TANYGNATHUS MEGALORHYNCHOS (Boddaert).

GREAT-BILLED PARROT.

On January 23 and October 8, 1906, this large green parrot was found in considerable numbers on Sarangani and Balut Islands of the Sarangani group, off southern Mindanao. An adult female (Cat. No. 200811, U.S.N.M.) was collected on Balut Island, January 23, 1906.

The following are believed to be new to science:

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<sup>a</sup> See Proc. Biol. Soc. Washington, XVIII, January 20, 1905, pp. 1-8; February 21, 1905, p. 73; February 21, 1905, pp. 83-90; June 29, 1905, p. 185; Philippine Journ. Sci., II, October, 1907, p. 353; pp. 355-360.

## PHAPITRERON SAMARENSIS, new species.

## SAMAR BROWN PIGEON.

*Type*.—Cat. No. 161096, U.S.N.M. Adult female. Collected in March, 1888, on the island of Samar, Philippine Islands, by Dr. F. S. Bourns.

*Characters*.—Resembling *Phapitreron brevirostris*, but with forehead, chin, and throat whiter than in *P. albifrons* McGregor. From *P. brevirostris* it is readily distinguishable by the white forehead, chin, and upper throat, also by the much greater amount of coppery amethystine reflections on the crown, breast, and upper back, and by the usual absence of green reflections on the side of the hind head below the suborbital white stripe; and the under parts are much paler. From *P. albifrons* it may be at once distinguished by the different color of the under parts, which lack the olivaceous-gray on the breast, and by its more ochraceous abdomen; also the coppery reflections on the breast and upper back of *P. samarensis* are entirely absent in *P. albifrons*.

*Measurements of type* (from well-made skin of female).—Total length, 230 mm.; wing, 124; tail, 95; culmen and cere (chord), 14; tarsus, 19; middle toe with claw, 26. "Eyes pink. Feet, base of mandible, and around eyes, dark purple. Tip of bill black. Egg taken from ovary." (F. S. Bourns.)

*Measurements of adult male* (Cat. No. 161095, U.S.N.M., collected in April, 1888, on the island of Samar, by Dr. F. S. Bourns).—Wing, 129 mm.; tail, 95; culmen and cere (chord), 14.5; tarsus, 20; middle toe with claw, 27.

## MUSCADIOVORES PALMASENSIS, new species.

## PALMAS ISLAND FRUIT-EATING PIGEON.

*Type*.—Cat. No. 200839, U.S.N.M. Adult male. Collected January 21, 1906, on Palmas Island, in the Celebes Sea, Philippine Islands, by Edgar A. Mearns. (Original number, 13889.)

*Characters*.—Closely related to *Muscadivores pickeringi* from Mangsee Island, north of Borneo, on the west side of the Sulu Sea; also to *Muscadivores langhornei* Mearns, from West Bolod Island, southeast of the Sulu Sea and near the island of Basilan. From the type of *pickeringi* (Cat. No. 15732 U.S.N.M.) it differs in being paler, with much less vinaceous color on the chin, throat, breast, and under tail-coverts. The wing is 10 mm. shorter. From *langhornei*, which it resembles more closely in the coloration of the under parts, it can be distinguished at a glance by the dark color of the mantle, rump, and upper tail-coverts.

*Adult male* (type, killed January 21).—Head, neck, upper back, and under parts, lilac-gray, purest on the upper side of neck and

upper back, washed with vinaceous on crown, ear-coverts, and breast, fading to whitish around base of bill, and shading to drab-gray on legs and crissum; scapulars, back, rump, and wing-coverts mouse gray, lustrous in a certain light; wing-quills and upper tail-coverts dark mouse gray, with subdued reflections of violet, coppery, and green; rectrices lustrous golden green above, smoke gray below; flanks, axillars, and lining of wings clear gray. An adult male topotype in fresh plumage, shot by Dr. Paul C. Freer, October 7, 1906, only differs from the type in being appreciably darker. The sexes are practically alike in size and color.

*Colors of soft parts.*—Two mated pairs, about to breed, had the soft parts colored exactly alike, January 21, 1906: Iris red; eyelids and feet vinaceous; claws dusky purplish gray; bare space surrounding eye, pale plumbeous; bill pale bluish gray at tip, darker—plumbeous—at base. Testicles functionally enlarged.

*Measurements of two adult males* (type and topotype measured fresh by the author).—Total length, 420, 430 mm.; alar expanse, 735, 750; wing, 240, 240; tail, 156, 160; culmen (chord), 20, 20; tarsus, 32, 34; middle toe with claw, 46, 49.

OTUS STEEREI, new species.

TUMINDAO SCOPS OWL.

*Type.*—Cat. No. 210752, U.S.N.M. Adult male. Collected by Edgar A. Mearns, October 13, 1906, on Tumindao Island, off Sitanki Island, Philippine Islands. (Original number, 14421.)

*Characters.*—Very similar to the Celebesian *Otus menadensis*, from which it may be distinguished by being larger, with upper parts darker, with more of the black vermiculations; black centers to the feathers of the under parts much less conspicuous; feathers of tarsus more heavily cross-barred with blackish. Of the Philippine species it is most closely related to *Otus cuyensis* McGregor, but is darker and much smaller, having the same white, black-tipped scapulars, but with the entire plumage darker and more heavily marked, and the wing about 15 mm. shorter. It bears no close resemblance to any other Philippine species.

*Measurements.*—Wing, 157 mm.; tail, 84; culmen from cere (chord), 15; tarsus, 33. Iris yellow; bill and feet greenish (from fresh specimen). The stomach of the type contained insects.

Named for J. B. Steere, known for his studies of Philippine birds.

PRIONITURUS MALINDANGENSIS, new species.

MOUNT MALINDANG RACQUET-TAILED PARROT.

*Type.*—Cat. No. 200887, U.S.N.M. Adult female. Collected at 5,000 feet altitude on Mount Lebo, a spur of Mount Malindang, Misamis Province, northwestern Mindanao, Philippine Islands, May 14, 1906, by Edgar A. Mearns. (Original number, 14131.)

*Characters*.—Closely related to *Prioniturus waterstradti* Rothschild, from Mount Apo, southeastern Mindanao, from which it may be distinguished by its larger size, much yellower coloring of under side, greener, less brownish back and scapulars, longer tail, but much shorter naked shafts to the central pair of feathers.

*Adult female* (type and only specimen).—Upper parts green, with slight touches of bluish on forehead, and a light greenish brown rump, as in *P. waterstradti*; wings bright green above, with concealed inner webs blackish, and outer webs narrowly edged with yellow; edge of wing pale yellow; rectrices green above tipped with dull black, beryl green on under side, the shafts and spatules of the central pair dull black, with webs all green to the naked shafts; entire under parts golden green; axillars and lining of wings oil green; under side of primaries dull black, broadly bordered on the inner webs with beryl green. Iris dark brown; bill pale horn color, faintly plumbeous at base and tip of mandibles; feet and claws plumbeous (from fresh specimen).

*Measurements of type* (female).—Wing, 153 mm.; tail, 79 (to end of lengthened central pair, 126); culmen from cere (chord), 20; tarsus, 16; middle toe with claw, 25.

*Measurements of adult female topotype of P. waterstradti* (Cat. No. 192136, U.S.N.M.).—Wing, 145 mm.; tail, 75 (to end of lengthened central pair, 151); culmen from cere (chord), 18; tarsus, 15; middle toe with claw, 25 (skin).

YUNGIPICUS SIASIENSIS, new species.

SIASI PIGMY WOODPECKER.

*Type*.—Cat. No. 210765, U.S.N.M. Adult male from Siasi Island, Philippines, collected October 12, 1906, by Edgar A. Mearns. (Original number, 14401).

Mr. E. Hargitt, in the original description of "*Yungipicus ramsayi*,"<sup>a</sup> gave the type-locality as "Northeast Borneo;" but the same author<sup>b</sup> says that the type was an adult male collected by A. Everett in the "Sulu Islands."

An adult male specimen (Cat. No. 211344, U.S.N.M.) collected by Dr. Paul Bartsch, February 23, 1908, on Papahag Island, off Tawi-Tawi, one of the southern islands of the Sulu group, agrees with Hargitt's *Yungipicus ramsayi*.

*Adult male* (type).—Similar to the male of *Y. ramsayi*, but with a smaller bill and without white markings on the upper surface of the primaries or secondaries except a small concealed white spot on inner webs of several secondaries, and with much less white on the inner

<sup>a</sup> Ibis, 1881, p. 598.

<sup>b</sup> British Museum Catalogue of Birds, XVIII, p. 335.



margins of the inner webs on under side of wing; and the orange-yellow of the under parts is much more restricted, being confined to a narrow band across the chest.

*Adult female* (Cat. No. 210746, U.S.N.M., killed at the same time and place as the type, with which it was apparently mated).—Similar to the male, but lacking the elongated scarlet feathers on the edge of the posterior half of the crown and occiput, the entire upper surface of head and neck being dark brown. The white markings of the upper and under sides of the wings are restricted to the same extent as those of the type, and tend to form a very narrow brownish-white margin to the inner webs of the innermost secondaries, below, instead of forming squarish detached white spots as in *Y. ramsayi*; the orange-yellow pectoral band as in the male.

*Measurements of Yungipicus siasiensis*.—Adult male (type): Wing, 83 mm.; tail, 47; culmen, 19.5. Adult female (Cat. No. 210764, U.S.N.M.; topotype): Wing, 85 mm.; tail, 49; culmen, 20.2.

*Measurements of Yungipicus ramsayi*.—Adult male (Cat. No. 211344, U.S.N.M.): Wing, 85 mm.; tail, 47; culmen, 18.

RHINOMYIAS RUFICAUDA MINDANENSIS, new subspecies.

MINDANAO RUFOUS-TAILED FLYCATCHER.

*Type*.—Cat. No. 190247, U.S.N.M. Adult male, collected by the writer at Pantar, Mindanao, Philippine Islands, August 24, 1903. (Original No. 12929.)

The series of this genus in the U. S. National Museum shows that there are three geographical forms of the rufous-tailed flycatcher, from the islands of Basilan, Mindanao, and Samar, respectively.

Compared with the Samar and Mindanao forms the Basilan form, *Rhinomyias ruficauda ruficauda*, has the under parts whiter, middle of chest grayer, sides of chest and flanks a grayer brown, with entire side of head slate-gray.

*R. mindanensis* and *samarensis* both have brown cheeks, and differ from each other in size, the Mindanao form being larger. The upper surfaces are of a lighter, more olivaceous, and less rufescent color.

*Measurements of Rhinomyias ruficauda (Sharpe).*

Museum No.	Collector's No.	Sex and age.	Locality.	Date.	Wing.	Tail.	Culmen.	Depth at angle of gonys.	Tarsus.	Collector.
201263	13939	Adult.....	Isabella, Basilan ..	Feb. 2, 06	mm. 72	mm. 58	mm. .....	mm. 10.5	mm. 17.5	Mearns.

*Measurements of Rhinomyias ruficauda mindanensis, new subspecies.*

Museum No.	Collector's No.	Sex and age.	Locality.	Date.	Wing.	Tail.	Culmen.	Depth at angle of gony.	Tarsus.	Collector.
190247	12929	Male ad...	Pantar, Mindanao..	Aug. 24, 03	mm. 74	mm. 60.5	mm. ....	mm. 11	mm. 17	Mearns. <sup>a</sup>
210837	14123	do.....	Catagan, Mindanao.	May 13, 06	77	64	.....	11	18	Do.
211161	17	Male.....	do.....	May 21, 06	76	67	.....	11	17.3	Schroder.
200953	14075	Male ad...	Zamboanga, Mindanao.	Apr. 25, 06	76	65	.....	12	18	Mearns.
190246	12893	Female ad.	Pantar, Mindanao..	Aug. 13, 03	73	56	.....	10	16	Do.
210836	14199	do.....	Catagan, Mindanao.	May 23, 06	74	60	.....	10.2	17	Do.
210838	14213	do.....	do.....	May 25, 06	74	60	.....	10.6	16	Do.

*Measurements of Rhinomyias samarensis Steere.*

161506	.....	Male ad....	Samar Island, P. I.	Mar. —, 88	73	62	9.8	.....	16	Bourns.
161505	.....	Female ad.	do.....	Apr. 23, 88	73	60	10.4	.....	17	Worcester.
161502	.....	do.....	do.....	Apr. 20, 88	68	56	11	.....	16	Do.
161504	.....	do.....	do.....	Apr. 2, 88	69	56	9.8	.....	15.8	Do.
161503	.....	do.....	do.....	Apr. 18, 88	71	60	11	.....	16	Do.

<sup>a</sup> Type.

## CRYPTOLOPHA MALINDANGENSIS, new species.

## MOUNT MALINDANG FLYCATCHER-WARBLER.

*Type*.—Cat. No: 202360, U.S.N.M. Adult male. Summit of Grand Malindang Mountain (altitude slightly above 9,000 feet), Misamis Province, northwestern Mindanao, Philippine Islands, June 6, 1906. Collected by Edgar A. Mearns. (Original number, 14275.)

*Characters*.—Similar to *Cryptolopha mindanensis* Hartert, from Mount Apo, Mindanao, but smaller, less yellow above and below, and with a distinct yellowish-white post-ocular streak extending to the occiput; bill flesh color instead of yellow on base of mandible; feet grayish flesh color instead of plumbeous.

*Adult male*.—Upper parts olive-green, darkest on the crown; wings and tail dark brown, broadly bordered with olive-green on the outer webs, but with outer rectrix white to the base, edged with pale yellow basally and with olive-brown terminally on outer web; second rectrix dark brown at base of inner web, white on terminal two-thirds, yellow on basal half of outer web, and olive-brown on terminal half; third rectrix edged with white at tip of inner web and yellow on outer web at base; loreal and post-ocular streak yellowish white; entire under parts sulphur yellow, obscured by pale olive-green centers to the feathers; under tail-coverts plain sulphur yellow; sides of chest and flanks olive-green, streaked with yellow; axillars and lining of wings pale sulphur yellow; cheeks pale sulphur yellow, mottled with very pale olive-green; iris hazel; bill brownish black, flesh color at base of mandible; feet grayish flesh color, claws brown (from fresh specimen).

*Comparative measurements of Cryptolopha mindanensis and C. malindangensis.*—Adult males (from skins): Wing, 58, 56 mm.; tail, 48, 46; bill from nostril, 7, 7; tarsus, 21, 21.

*Material.*—Five specimens of *Cryptolopha mindanensis* and 11 of *C. malindangensis*.

*Range.*—From 5,000 to 9,000 feet on the Malindang Mountains.

PSEUDOTHARRHALEUS MALINDANGENSIS, new species.

MOUNT MALINDANG WOOD-ACCENTOR.

*Type.*—Cat. No. 210853, U.S.N.M. Adult male. Summit of Mount Malindang, northwestern Mindanao, Philippine Islands, altitude slightly above 9,000 feet, June 6, 1906. Collected by Edgar A. Mearns. (Original number, 14277.)

*Characters.*—The largest known species of *Pseudotharrhaleus*; gray of cheeks and supraorbital stripe obscured by heavy markings of brown; feathers of chest heavily marked with black centers.

*Adult male* (type and only specimen).—General color above burnt umber, washed with Vandyke brown on rump and upper tail-coverts; tail darker; wing-quills brownish black, with outer webs broadly margined with the same color as the upper parts and extending to the outer webs of the under side of wing; head sepia above, without an appreciable supraorbital stripe; sides of head grayish brown, maculated with bister; chin and upper throat dirty whitish; much obscured by dusky macules occupying the centers of the feathers; middle of chest gray, heavily marked with blackish centers to the feathers; sides, crissum and under tail-coverts, axillars, and lining of wings like the back, this color shading to wood brown on middle of belly; iris brown; bill plumbeous-black; feet and claws brown (from fresh specimen). The following measurements were taken from the type specimen, freshly killed, by the writer: Total length, 196 mm.; alar expanse, 212; wing, 66; tail, 90; culmen (chord), 16.5; bill from nostril, 10.3; from occiput to tip of bill, 42; tarsus, 28; middle toe with claw, 25.

This bird was usually found in hollows under mossy logs. Its note resembles the alarm call of the American *Pipilo fuscus mesoleucus*.

BRACHYPTERYX MALINDANGENSIS, new species.

MOUNT MALINDANG SHORTWING.

*Type.*—Cat. No. 202137, U.S.N.M. Adult female. Summit of Grand Malindang Mountains, altitude 9,000 feet, Misamis Province, northwestern Mindanao, Philippine Islands, June 5, 1906. Collected by Edgar A. Mearns. (Original number 14269.)

*Characters.*—Most closely related to *Brachypteryx brunneiceps* Grant and *B. mindanensis* Mearns. Smaller than *brunneiceps*, about equaling *mindanensis*; coloration very dark; russet of front of head

intensified to almost a burnt umber, and not extending backward beyond the eyes; edge and lining of wings, slate color, instead of rusty.

*Adult male*.—(Cat. No. 202136, U.S.N.M. A topotype from the summit of Mount Malindang, altitude 9,000 feet, June 5, 1906).—Uniformly slate-black, becoming practically black on the whole head, except a minute and wholly concealed supraorbital white spot. Iris dark reddish brown; bill all jet black; feet and claws plumbeous-black (from fresh specimen).

*Adult female* (type).—Front of head back to the eyes rusty burnt umber, with eye-ring of same color; hind half of head, neck all round, and all of body except abdomen, blackish slate; abdomen washed with brownish gray; wings and tail brownish black, washed with slate-color; edge and lining of wings slate-color, not russet. The colors of the iris, bill, and feet were noted as exactly like those of the male topotype.

*Measurements*.—*Adult male* (Cat. No. 202136, U.S.N.M.): Total length, 160 mm.; alar expanse, 222; wing, 70; tail, 60; culmen (chord), 14.5; bill from nostril, 9; tarsus, 32; middle toe with claw, 24. *Adult female* (type): Total length, 148 mm.; alar expanse, 213; wing, 66; tail, 53; culmen (chord), 13; bill from nostril, 8.5; tarsus, 34; middle toe with claw, 24.5.

HYLOTERPE APOENSIS BASILANICA, new subspecies.

BASILAN ISLAND THICK-HEAD.

*Type*.—Cat. No. 161534, U.S.N.M. Adult male. Collected on the island of Basilan, Philippine Islands, November 8, 1887, by D. C. Worcester.

*Adult male*.—Similar to typical *Hyloterpe apoensis*, but paler throughout, with crown brownish instead of grayish; underparts canary yellow instead of lemon yellow; slightly smaller. Wing, 78 mm.; tail, 67; culmen, 14; bill from nostril, 9.2; tarsus, 17.5; "Iris brown. Bill black."

*Adult female*.—(Cat. No. 201258 U.S.N.M. Collected on the island of Basilan, Philippine Islands, February 19, 1906, by Edgar A. Mearns. Original number, 13962). Paler and dingier than the male; under parts pale canary yellow from throat backward. Wing, 71 mm.; tail, 61; tarsus, 17.5.

*Remarks*.—Specimens in the U. S. National Museum, collected on the island of Siquijor, Philippine Islands, by F. S. Bourns and D. C. Worcester, are exactly like Basilan specimens taken in February, 1888, and must be included as belonging to this subspecies. Lowland birds from Mindanao Island connect the forms *apoensis* and *basilanicæ*.



## ZOSTEROPS GOODFELLOWI MALINDANGENSIS, new subspecies.

## MOUNT MALINDANG SILVER-EYE.

*Type*.—Cat. No. 202401, U.S.N.M. Adult male. Summit of Mount Lebo (Malindang group), altitude 5,750 feet, Misamis Province, northwestern Mindanao. May 21, 1906. Collected by Edgar A. Mearns (original number 14169).

*Characters*.—Smaller than typical *Zosterops goodfellowi*, with stouter bill, front half of head grayish brown instead of olive-green; nape greenish gray instead of olive-green; auricular patch more sharply defined and less greenish; malar region washed with brown instead of being dirty white; throat and upper breast more distinctly washed with brown. The iris is reddish brown in both; bill black in *malindangensis*, plumbeous-black in *goodfellowi*; feet and claws pale olive, yellowish on under side of toes in both.

*Measurements of Zosterops goodfellowi goodfellowi and Zosterops goodfellowi malindangensis contrasted*.—Adult males (measured in the flesh by the writer): Total length, 156–147 mm.; alar expanse, 231–218; wing, 75–70; tail, 61–57; culmen (chord) 13–15; tarsus, 21–21; middle toe with claw, 16–16.5. Adult females (measurements from dry skins): Wing, 70–63 mm.; tail, 59–54; culmen (chord), 12.5–13.5; tarsus, 21–21.

*Material*.—Seven specimens of typical *goodfellowi* from Mount Apo and eleven of the present form from the Malindang group of mountains.

*Range*.—From 5,000 feet on Lebo and Bliss peaks up to the summit of Grand Malindang (9,000 feet).

## CYRTOSTOMUS JUGULARIS MINDANENSIS, new subspecies.

## MINDANAO YELLOW-BREASTED SUNBIRD.

*Type*.—Cat. No. 192061, U.S.N.M. Adult male. Collected January 24, 1904, at Zamboanga, western Mindanao, Philippine Islands, by Edgar A. Mearns. (Original number, 13177.)

*Characters*.—Most closely resembling *Cyrtostomus jugularis jugularis* of Luzon, but slightly larger, with the upper parts olive-green instead of brownish olive-gray; under parts nearly uniform lemon yellow instead of canary yellow.

*Comparative measurements*.—Males of *Cyrtostomus jugularis mindanensis* average: Wing, 54 mm.; tail, 44; culmen (chord), 18; tarsus, 15. Males of *C. j. jugularis* average: Wing, 50 mm.; tail, 40; culmen, 18; tarsus, 15. Females of *C. j. mindanensis* average: Wing, 52 mm.; tail, 38; culmen, 18; tarsus, 14. Females of *C. j. jugularis* average: Wing, 48 mm.; tail, 38; culmen, 17; tarsus, 14.

*Material*.—Twenty-six skins, from Mindanao and the offlying islands of Talicud and Buluan, the latter showing a tendency to

intergrade with *C. j. woodi*. One skin from Cebu Island appears to be this form.

*Remarks*.—Skins from northern Mindanao, adjoining the range of *C. jugularis dinagatensis* (Bucas, Dinagat, Leyte, Bohol, and Panay islands) show no tendency to intergrade with *dinagatensis*, but, on the contrary, have the under parts paler yellow than any others from Mindanao. The range of *dinagatensis* separates the ranges of *jugularis* and *mindanensis*.

CYRTOSTOMUS JUGULARIS WOODI, new subspecies.

WOOD YELLOW-BREASTED SUNBIRD.

*Type*.—Cat. No. 200602, U.S.N.M. Adult male from one of the "Three Islands," south of Sibutu Island, Philippine Islands, January 5, 1906. Shot by Leonard Wood, jr., for whom the species is named.

*Characters*.—Smaller than *Cyrtostomus jugularis aurora*, *C. jugularis jugularis*, or *C. jugularis dinagatensis*, old males differing from all three in the metallic reflections on the middle of the dark metallic plastron, which are bluish and violet instead of green-blue; under parts shading *very gradually* from rich orange, adjoining the dark metallic plastron, to clear yellow on the crissum and under tail-coverts; back a more golden olive-green than in the other Philippine forms; forehead, lores, and superciliary stripe solid metallic violet-purple.

*Young male* (Cat. No. 200600, U.S.N.M., from Dammi Island, in the Sulu Sea, January 4, 1906).—Middle of chin, fore neck, and throat metallic blue; sides of neck and chest orange-yellow, shading to canary yellow on crissum and under tail-coverts; upper parts golden olive-green; quills dark grayish brown, edged with olive-green, like the back; rectrices tipped with yellowish white, broadest externally.

*Measurements of type* (skin).—Wing, 52 mm.; tail, 40; culmen (chord), 16.5; bill from nostril, 14; tarsus, 14.5; middle toe with claw, 11.5.

*Geographical range*.—Known only from three islets south of Sibutu Island, and from Dammi Island. There being no specimens from the neighboring small islands, it is not possible to define its range at the present time.

Description of the female of *Cyrtostomus jugularis dinagatensis*.

DINAGAT ORANGE-BREASTED SUNBIRD.

No. 202451 from Bucas Island, Philippine Islands, October 4, 1906. Shot by Capt. Halstead Dorey, U. S. Army. Similar to females of *C. j. jugularis*, but greener above and paler yellow below.

This proves to be a very distinct form, having for its range the islands of Bucas, Dinagat, Leyte, Bohol, and Panay.

Description of female of *Anthreptes cagayanensis* Mearns.

## CAGAYAN SULU BROWN-THROATED SUNBIRD.

*Characters of adult female* (Cat. No. 202463 U.S.N.M., collected October 15, 1907, on Cagayan Sulu Island, in the Sulu Sea, Philippine Islands, by Edgar A. Mearns).—Differs from females of *Anthreptes griseigularis* in the absence of the grayish white chin and throat; from *A. chlorogaster* in the yellower coloration of the middle underparts and greener upper parts; and from *A. malaccensis* only in the greater contrast of the canary yellow of the middle underparts with the green color of the flanks, which in *A. cagayanensis* are pale oil-green, and in *A. malaccensis* olive-yellow. I have no female of *A. wigglesworthi* for comparison. Wing, 65 mm.; tail, 47; culmen (chord), 15.5; bill from nostril, 12; tarsus, 15.8.

## PYRRHULA STEEREI, new species.

STEERE BULLFINCH.<sup>a</sup>

*Type*.—Cat. No. 210772, U.S.N.M. Adult male. Summit of Mount Bliss, Malindang group, altitude 5,750 feet, northwestern Mindanao, Philippine Islands, June 9, 1906. Collected by Edgar A. Mearns (original number 14278).

*Characters*.—Similar to *Pyrrhula leucogenys* Grant,<sup>b</sup> from the mountains of Lepanto in northern Luzon. The Mindanao bird differs in being smaller, with a differently colored, much smaller bill, more brownish coloration, and a tendency to whitening on the middle of the abdomen, which the Luzon bird lacks.

*Adult male* (type, killed July 9).—Crown and front of head all round, to just behind eye, black; crown glossed with purplish blue; lores, malar region, chin, and upper throat dead black; auriculars white; scapulars and interscapular region deep broccoli brown; rump white; rectrices, upper tail-coverts, primaries, secondaries, tertials, primary coverts, and base of greater wing-coverts, glossy bluish black; lesser wing-coverts dark broccoli brown; terminal two-fifths of greater wing-coverts broccoli brown, paler terminally; outer web of innermost secondary edged externally with orange-vermilion; under parts broccoli brown, shading to whitish on middle of belly and to tawny ochraceous on crissum; axillars pure white; under wing-coverts brown at base, broadly white terminally; underside of shafts of primary quills white nearly to the tips. Fresh specimens, including the type, were noted in the field as having the iris dark brown; bill plumbeous-black, perceptibly horn color at extreme base; feet

<sup>a</sup> The section to which this bullfinch belongs has recently been made the subgenus *Protopyrrhula* Bianchi. Bull. Acad. Imp. Sci., St. Petersburg, 5th ser., XXV, 1906, pp. 159–198. Subgenus for *P. nipalensis*, *erythrocephala*, *erythaca*, and *leucogenys*.

<sup>b</sup> Described in the Bulletin of the British Ornithologists' Club, No. XXVIII, p. XLI, June 29, 1895.



brownish flesh color, with under side of toes yellowish; claws brown. In the dry skins the bills are uniformly plumbeous-black.

*Adult female* (Cat. Nos. 202265 and 210771, U.S.N.M., topotypes taken May 27 and 30, respectively).—Exactly like the male, except that the outer web of the innermost secondary is edged externally with yellowish orange instead of orange-vermilion.

*Comparison with Pyrrhula leucogenys*.—The material used in making the comparison with *Pyrrhula leucogenys* consists of two adult females of *P. leucogenys*, one (Cat. No. 172435, U.S.N.M.) a topotype collected by Mr. John Whitehead in Lepanto Province, Luzon, the other (Cat. No. 208435, U.S.N.M.) collected by the author near Paoay, Benguet Province, Luzon. The first was killed December 19, 1894, the second July 28, 1907. The December bird is in fresher plumage and somewhat darker and browner than the July specimen. The two localities were in sight of each other, perhaps 20 miles apart. In both of the Luzon birds the bills still show a large amount of yellow, as shown in Mr. Keuleman's excellent figures of the male and female (Plate 14) published in the Ibis for 1895, opposite page 455. From a female specimen of *P. leucogenys* (Cat. No. 208435, U.S.N.M.) just shot I noted the following: Iris grayish brown; bill yellowish horn color, broadly black on commissural line and at tip; feet brownish flesh color; claws darker brown.

*Comparative measurements of fresh specimens* (by the author).—Cat. No. 210771, U.S.N.M., an adult female topotype of *Pyrrhula steerei*, and Cat. No. 208435, an adult female of *P. leucogenys*, from near the type locality, presented the following measurements: Length, 152, 168 mm.; alar expanse, 242, 259; wing, 77, 82; tail, 65, 71; culmen (chord), 10.5, 11.3; tarsus, 17.5, 18.5; middle toe with its claw, 16.5, 19.

*Remark*.—It seems fitting that this species should be named in honor of Prof. J. B. Steere, who has contributed so much to our knowledge of Philippine birds.

In the following table measurements of *Pyrrhula leucogenys* and *P. steerei*, taken from dry skins, by Mr. J. H. Riley, are presented.

Measurements of *Pyrrhula leucogenys*.

Museum No.	Museum.	Sex and age.	Locality.	Date.	Wing.	Tail.	Culmen.	Depth at angle of gonyx.	Tarsus.	Middle toe with claw.	Breadth of bill.
172435	U. S. .	Female ad.	Lepanto, North Luzon.	Dec. 19	mm. 81.5	mm. 61.5	mm. 11.5	mm. 11	mm. 17.5	mm. 19.5	mm. 10
208435	...do...	...do.....	Near Paoay, Benguet, Luzon.	July 28	79.5	64	11.5	11	18	19	10.5



*Measurements of Pyrrhula steerii.*

Museum No.	Museum.	Sex and age.	Locality.	Date.	Wing.	Tail.	Culmen.	Depth at angle of gonyx.	Tarsus.	Middle toe with claw.	Breadth of bill.
202265	U. S.	Female ad.	Summit of Mount Bliss, Mindanao.	May 27	mm. 77	mm. 61	mm. 10.5	mm. 9.5	mm. 17	mm. 17	mm. 9
210771	...do...	...do...	...do...	May 30	78	60	10	9.5	17	17	9.5
210772	...do...	Male ad.	...do...	June 9	77	60.5	10.5	9.5	16.5	16.5	9.5

## DICRURUS BALICASSIUS MINDORENSIS, new subspecies.

## MINDORO DRONGO SHRIKE.

*Type*.—Cat. No. 202009, U.S.N.M. Adult male, collected at 3,000 feet altitude on Mount Halcon, Mindoro Island, November 30, 1906, by Edgar A. Mearns.

*Characters*.—Slightly larger than *Dicrurus balicassius* from Luzon Island; also differing in having the metallic reflections of the upper parts and breast greenish blue instead of bluish green.

*Measurements of type* (adult male).—Wing, 148 mm.; tail, 130; culmen, 27; tarsus, 25.

*Measurements of three adult female topotypes* (Cat. Nos. 202006–8, U.S.N.M.).—Wing, 143, 146, 144 mm.; tail, 128, 129, 129; culmen, 27.5, 31, 29; tarsus, 26, 25, 25.

## CHIBIA CAGAYANENSIS, new species.

## CAGAYAN SULU DRONGO SHRIKE.

*Type*.—Cat. No. 191894, U.S.N.M. Adult female from Cagayan Sulu Island, in the western part of the Sulu Sea, Philippine Islands, collected February 26, 1904, by Edgar A. Mearns. (Original number, 13285.)

*Characters*.—Very similar to *Chibia palawanensis*, differing only in its somewhat larger size, shallower forking of the tail, the narrower and very much smaller spangles on the breast, and in the absence of metallic green on the upper tail-coverts.

*Measurements of skin* (type and only specimen).—Length, 260 mm.; wing, 136; tail, 126; emargination of tail, 16; culmen (chord), 28.5; tarsus, 24.5.

*Measurements of two adult female topotypes of Chibia palawanensis* (Cat. Nos. 161330 and 161331, U.S.N.M.).—Length, 157, 150 mm.; wing, 133, 131; tail, 126, 130; emargination of tail, 20, 20; culmen, 28, 27; tarsus, 23, 25.5.

*Remark*.—I saw a number of these birds on the island of Cagayan Sulu on my brief first visit.



## REMARKS ON THE INSECTIVORES OF THE GENUS GYMNURA.

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An examination of nearly two dozen specimens of the genus *Gymnura* in the United States National Museum shows that in addition to the two distinct species usually recognized, a third form, from the northern portion of the Malay Peninsula, must be considered. It is here described for the first time as a subspecies of the older of the two species.

As there is some lack of agreement among authors regarding the limits of the genus *Gymnura*, it will not be out of place to consider some of its characteristics before describing the new subspecies. Dobson,<sup>a</sup> Flower and Lyddeker,<sup>b</sup> and Trouessart<sup>c</sup> have included under the term *Gymnura* certain small short-tailed species, which other writers, Thomas<sup>d</sup> and Max Weber,<sup>e</sup> for instance, regard as constituting a separate genus *Hylomys*. I quite agree with the opinion of these latter, and in order to show the distinctness of *Gymnura* from *Hylomys* figures of their skins and skulls are shown on Plates 34 to 37. In order to make the relations of the genus *Gymnura* still clearer, the entire animal and the extracted skull of the unique specimen of the recently discovered and related genus *Podogymnura*,<sup>f</sup> an animal unknown to the authors cited, are shown on the plates 36 and 37.

*Gymnura* is here considered as one of three genera forming the subfamily Gymnurinae, the other two being *Hylomys* and *Podogymnura*. In respect to size and external characteristics *Hylomys* and *Podogymnura* appear to be closely related to one another. (Plate 37.) An examination of the teeth, however (Plate 36), shows that these

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<sup>a</sup> Monogr. Insectivora, 1882, p. 5.

<sup>b</sup> Introd. Study of Mammals living and extinct, 1891, p. 620.

<sup>c</sup> Cat. Mamm. Suppl., 1904, p. 126.

<sup>d</sup> Ann. Mag. Nat. Hist., 6th ser., II, November, 1888, p. 407.

<sup>e</sup> Die Säugetiere, 1904, p. 379.

<sup>f</sup> Mearns, Proc. U. S. Nat. Mus., XXVIII, No. 1402, p. 437, May 13, 1905.

two genera are very distinct. The premolars both above and below in *Hylomys* are  $\frac{4}{4}$ , in *Podogymnura*  $\frac{3}{3}$ . The three anterior premolars in *Hylomys* are small, practically functionless teeth, while in *Podogymnura* the penultimate premolar is well developed and trenchant, standing nearly as high in the tooth row as the last premolar (Plate 36). The premolars in *Gymnura* are  $\frac{4}{4}$ , as they are in *Hylomys*. The two anterior of them are small and practically functionless, like the three anterior premolars of *Hylomys*; the two posterior are large and trenchant, like the two posterior premolars of *Podogymnura*. (Compare Plates 35 and 36.) Of the three genera *Gymnura* appears to be the most generalized and primitive, and from it or its ancestors the other two genera have been derived. In the shortening of the tail and simplification in the structure of the premolars *Hylomys* has departed further from *Gymnura* than has *Podogymnura*. The last upper molar of *Podogymnura* and *Hylomys* shows a more simple structure than the corresponding tooth of *Gymnura*, which has a distinct posterior heel, lacking in the other two genera. The genus *Gymnura* is said to present the most generalized structure known among placental mammals.<sup>a</sup> An account of its anatomy is given in Dobson's Monograph of the Insectivora, 1882.

The geographic distribution of the genus coincides with part of the Malayan subregion of the Oriental region, namely, Tenasserim, the Malay Peninsula, Sumatra, and Borneo, and a few immediately adjacent islands. So far as known, it does not occur on others of the larger or of more remote smaller islands of the Malayan Archipelago.

Although the existence of two species in the genus had been pointed out by Giebel in 1863,<sup>b</sup> yet they were usually considered as mere local varieties, or color phases, until Jentink reaffirmed their specific distinction in 1881.<sup>c</sup> Jentink and other writers have described certain peculiarities of shape in the skull and teeth by which the two species in the genus may be distinguished, but I have been unable to detect any other peculiarities than size and color for distinguishing them. The skulls and teeth, however, show many individual variations, but none of them are constant for definite geographic areas. The characters assigned by other writers may probably be explained as the result of examining too small a number of specimens.

The different members of the genus may be distinguished by the following key:

KEY TO THE SPECIES AND SUBSPECIES OF GYMNURA.

- a. Color uniformly white or whitish, size large, hindfoot 66-74 mm., basal length of skull 76-84-----*Gymnura alba*, p. 453

<sup>a</sup> Huxley, Proc. Zool. Soc. London, 1880, p. 657.

<sup>b</sup> Zeitschr. Ges. Naturw., XXII, p. 277.

<sup>c</sup> Notes Leyden Mus., III, pp. 166-168.



- b. Color black with some white on head and shoulders, size medium or small, hindfoot 58-68 mm., basal length of skull 67-78.—*Gymnura gymnura*, p. 451
- a.<sup>1</sup> Size medium; hindfoot, 61-68 mm.; basal length of skull 71-78.  
*G. g. gymnura*, p. 451
- b.<sup>2</sup> Size small; hindfoot 58-59 mm.; basal length of skull 67-71.  
*G. g. minor*, p. 453

## GYMNURA GYMNURA (Raffles).

*Diagnostic characters*.—Size small or medium; hindfoot 58-68 mm.; basal length of skull 61-78; color generally black, with white markings on head. See fig. 3, Plate 34.

*Color*.—General color black or blackish, except lips, chin, cheeks, an irregular V-shaped patch on top of head, and terminal fourth or more of tail white or whitish. About the shoulders and on upper back are numerous long hairs with long white or whitish tips. Similar hairs, but much shorter, occur on the throat.

*Pelage*.—The pelage is composed of two kinds of hairs, short (10-15 mm.) soft underfur of a dull blackish, brownish or dark drab-gray color, except about lips and cheeks, where it is white or whitish; and long, coarse, bristly hair, 50-60 mm. in length uniformly black in color, except in the region of the light markings about head and shoulders, where the long hairs are white throughout their extent or else have long white tips. About the head the long hairs are much shorter than over the rest of the body. On the underparts the long hairs are relatively few, soft, and short.

*Tail*.—The tail is covered with small scales about 10 to the centimeter, each scale subtended by about 3 hairs. On the dorsal surface of the tail the hairs are inconspicuous and a little longer than a scale in length; on the underside they are more conspicuous and equal 3 or 4 scales in length.

*Distribution*.—Tenasserim, Malay Peninsula, Sumatra.

*Remarks*.—This species is separable into two distinct races, a smaller one from Tenasserim, and Trong, Lower Siam, described below as new, and the typical race found on the lower end of the Malay Peninsula and on Sumatra.

## GYMNURA GYMNURA GYMNURA (Raffles).

1822. *Viverra gymnura* RAFFLES, Trans. Linn. Soc. London, XIII, p. 272. (Type-locality, probably Bencoolen, Sumatra.)
1827. *Gymnura rafflesii* LESSON, Man. Mamm., p. 171. (May 1827. See Palmer, North Amer. Fauna, no. 23, 1904, p. 304.)
1827. *Gymnura rafflesii*, HORSFIELD and VIGORS, Zool. Journ., III, p. 248. pl. VIII. (October, 1827. See Palmer, North Amer. Fauna, no. 23, 1904, p. 304.)

*Diagnostic characters*.—A large race of *Gymnura gymnura*, hind foot, 61-68; basal length of skull, 71-78.

*Color*.—As described above under *G. gymnura*.

*Skull and teeth.*—These are relatively large and heavy, otherwise they do not differ from those of the race described below. See fig. 2, Plate 35.

*Distribution.*—The U. S. National Museum contains specimens from Rumpin River, Pahang, Malay Peninsula; Singapore; Tapanuli Bay, west coast of Sumatra; the Siak region of eastern Sumatra, and Pulo Tebing Tinggi, a low alluvial island off the east coast of Sumatra. This form is probably generally distributed throughout Sumatra and the lower extremity of the Malay Peninsula.

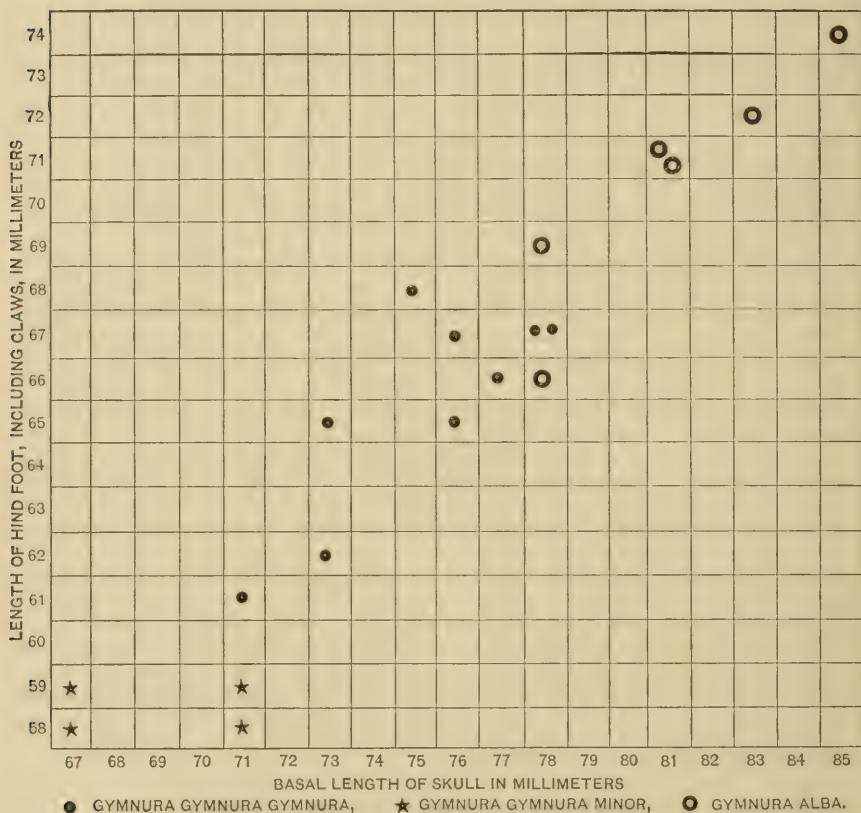


DIAGRAM TO SHOW THE RELATIVE SIZES OF THE THREE FORMS IN THE GENUS *GYMNURA* AS DETERMINED BY LENGTH OF HIND FOOT, INCLUDING CLAWS, AND OF BASAL LENGTH OF SKULL. MEASUREMENTS ARE IN MILLIMETERS. EACH DOT REPRESENTS AN ACTUAL SPECIMEN.

*Remarks.*—What is apparently an albino specimen of this race is recorded by Schneider<sup>a</sup> as *Gymnura alba*. He remarks, however, that it is distinctly smaller than white examples that he has seen from Borneo. Aside from color, difference in size is apparently the only manner by which Bornean and Sumatran examples may be distinguished. Schneider himself thought his example only a "sport."

<sup>a</sup> Zool. Jahrb. Syst., XXIII, 1905, p. 89.

*GYMNURA GYMNURA MINOR*, new subspecies.

*Type*.—Skin and skull of adult male, Cat. No. 86783, U.S.N.M., collected at Trong, Lower Siam (on Khow Nok Ram, 2,000 feet altitude), January 12, 1899, by Dr. W. L. Abbott.

*Diagnostic characters*.—Similar in all respects to the typical race, but averaging distinctly smaller throughout. See fig. 1, Plate 34.

*Color*.—The color of *Gymnura gymnura minor* does not differ essentially from that of *G. g. gymnura*, but there is a tendency to have more white about the head, neck, shoulders, and upper portion of back, as well as a narrower and less conspicuous black superciliary stripe.

*Skull and teeth*.—These possess the same relative shapes and proportions in *Gymnura gymnura minor* as they do in *G. g. gymnura*, but average distinctly smaller throughout. See fig. 1, Plate 35.

*Measurements*.—A series of four adults, all from Trong, give the following extremes of measurements: Head and body, 311–335 mm.; tail, 216–241; hind foot, with claws, 58–59; basal length of skull, 67–71; upper tooth row (all teeth, alveoli), 40–42. See table, page 455.

*Specimens examined*.—Four from the type-locality, 2 from an altitude of 2,000 feet, 1 from 1,000 feet. The altitude for the remaining specimen is not known.

*Distribution*.—Trong, Lower Siam, extending northward into Tenasserim. The small size of individuals from the latter country has been mentioned by both Dobson<sup>a</sup> and Blandford.<sup>b</sup> Bonhote<sup>c</sup> remarks that “the Malayan form appears to be smaller than the Sumatran race.”

*GYMNURA ALBA* Giebel.

1863. *Gymnura alba* GIEBEL, Zeitschr. Ges. Naturw., XXII, 1863, p. 277. (Type-locality, Borneo.)

1876. *Gymnura rafflesii* var. *candida* GÜNTHER, Proc. Zool. Soc. London, 1876, p. 425. (Type-locality, “Labuan, the mainland opposite Labuan, and Sarawak,” Borneo.)

*Diagnostic characters*.—Color entirely white or essentially so, largest member of the genus, hind foot 66–73 mm., basal length of skull, 78–85.

*Color*.—Everywhere white or dirty white or cream color, with the exception of a few long hairs on the back which have long black tips. See fig. 2, Plate 34.

*Pelage and tail*.—Except for color these have the same characters in *Gymnura alba* that they do in *G. gymnura*.

<sup>a</sup> Monogr. Insectivora, p. 4.

<sup>b</sup> Fauna British India, Mammals, p. 221.

<sup>c</sup> Journ. Fed. Malay States Mus., III, p. 3, 1908.

*Skull and teeth.*—These possess the same relative shapes and proportion as they do in *Gymnura gymnura*, but are distinctly larger throughout. See fig. 3, Plate 35.

*Measurements.*—See table, page 455, and diagram, page 452.

*Distribution.*—Borneo and the off-lying island of Labuan. Specimens in the U. S. National Museum are from along the Sempang River, southwestern Borneo.

*Remarks.*—I have been unable to find any constant character, aside from size and color, to distinguish between *Gymnura gymnura* and *G. alba*.

As in point of size the two species of *Gymnura* overlap one another slightly, it would be impossible to identify positively a large albino specimen of *G. gymnura* or a small individual of *G. alba*. A black individual is mentioned by Dobson <sup>a</sup> as possibly coming from Borneo. The size relationships of the three forms on the basis of hind foot and basal length of skull are shown by the diagram, page 452.

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<sup>a</sup> Monogr. Insectivora, p. 4.



External and cranial measurements of *Gymnura gymnura* and *G. alba*.

Name	Locality.	Cat. No.	Sex.	Teeth.	Basioecipito-sphenoid suture.	Head and body. <sup>a</sup>	Tail. <sup>a</sup>	Hind foot with claws. <sup>b</sup>	Basal length of skull.	Palatal length.	Zygomatic width.	Upper tooth row; all teeth (alveoli).	Mandible, front of symphysis to back of condyle.	Mandibular tooth row; all teeth (alveoli).
<i>G. gymnura gymnura</i> ...	Pahang: R u m p i n River.	115489	Male.	Slightly worn.	Practically obliterated.	410	270	mm. 67	78.5	51	39.5	46.5	66.4	41.2
Do.	Singapore	3767		Much worn.	Distinct, but closed.	377	255	61	71	46	38	42.5	60	37.3
Do.	Sumatra: T a p a n u l i Bay.	114551	Male.	Distinctly worn.								43	57.9	37.3
Do.	Sumatra: Little Siak River.	144172	do.	do.	Obliterated.	372	253	66	77	50	38.5	46	63	39.9
Do.	do.	144173	do.	Very slightly worn.	Practically obliterated.	365	250	62	73	48	38	43.1	60	36.4
Do.	do.	144171	Female.	Distinctly worn.	do.	402	263	67	78	51	41	45.7	62.3	40
Do.	do.	144174	do.	Much worn.	do.	371	250	65	76	48	40	44	60.2	38.4
Do.	Sumatra: M a n d a u River.			Distinctly worn.	Nearly obliterated.	382	280	67	76.5	49	38.5	45	62.3	38.8
Do.	Sumatra: Pulo Tebing	144329	do.											
Do.	Tingli.	144330	do.	Unworn.	Distinct and open.	370	260	68	75	49	36.5	45	60	39.3
Do.	do.	144331	do.	Traces of wear.	do.	390	240	65	73.5	47.2	37.5	44.5	61	38.4
<i>G. gymnura minor</i> .	do.	144331	do.	do.	Distinct, but closed.	330	241	59	71	43.5	36	41.5	56.1	36.5
Do.	Lower Siam: Trong.	83499	Male.	Slightly worn.	Distinct and open.	324	235	59	67	43	36.2	40.5	55.2	35.2
Do.	do.	86783	do.	do.	Nearly obliterated.	335	216	53	71	45	36	42	56.4	36.7
Do.	do.	86783	Female.	Distinctly worn.	Distinct and open.	311	232	58	67	42.5	35	40	52	35.7
Do.	do.	86784	do.	Unworn.	do.	389	263	71	81	51.6	42	47.6	63.8	41.7
<i>G. alba</i> .	S. W. Borneo: Sem-pang River.	145583	Male.	Practically unworn.										
Do.	do.	145584	do.	Distinctly worn.	Practically obliterated.	445	250	72	84.5	53.3	41.5	48.6	66.8	41.5
Do.	do.	145581	Female.	Traces of wear.	Distinct, but closed.	392	190	66	76.6	49.3	45	43.8	61.4	39.3
Do.	do.	145582	do.	Distinctly worn.	Practically obliterated.	420	262	74	85.5	55.2	45	49.8	67.1	43
Do.	do.	145585	do.	Slightly worn.	Distinct, but closed.	410	278	69	78.2	50	42.3	46	64.5	40
Do.	do.	145586	do.	do.	do.	405	205	71	81.4	52.3	42.3	47.8	64.8	41.3

<sup>a</sup> Measured by writer from dried skins.<sup>b</sup> Collector's measurements.<sup>c</sup> Type.

## EXPLANATION OF PLATES.

PLATE 34 (about  $\frac{1}{4}$  natural size).

- FIG. 1. Skin of *Gymnura gymnura minor*, adult female, Cat. No. 86784, U.S.N.M., Trong, Lower Siam, 2,000 feet altitude, collected by Dr. W. L. Abbott.
2. Skin of *Gymnura alba*, adult female, Cat. No. 145585, U.S.N.M., Sempang River, western Borneo, collected by Dr. W. L. Abbott.
3. Skin of *Gymnura gymnura gymnura*, adult male, Cat. No. 144173, U.S.N.M., Little Siak River, east coast of Sumatra, collected by Dr. W. L. Abbott.

PLATE 35 ( $\frac{2}{3}$  natural size, dorsal, lateral, and ventral views of skulls).

- FIG. 1. *Gymnura gymnura minor*, Cat. No. 86783, U.S.N.M. Type, Trong, Lower Siam.
2. *Gymnura gymnura gymnura*, Cat. No. 144171, U.S.N.M., Little Siak River, Sumatra.
3. *Gymnura alba*, Cat. No. 145584, U.S.N.M., Sempang River, western Borneo.

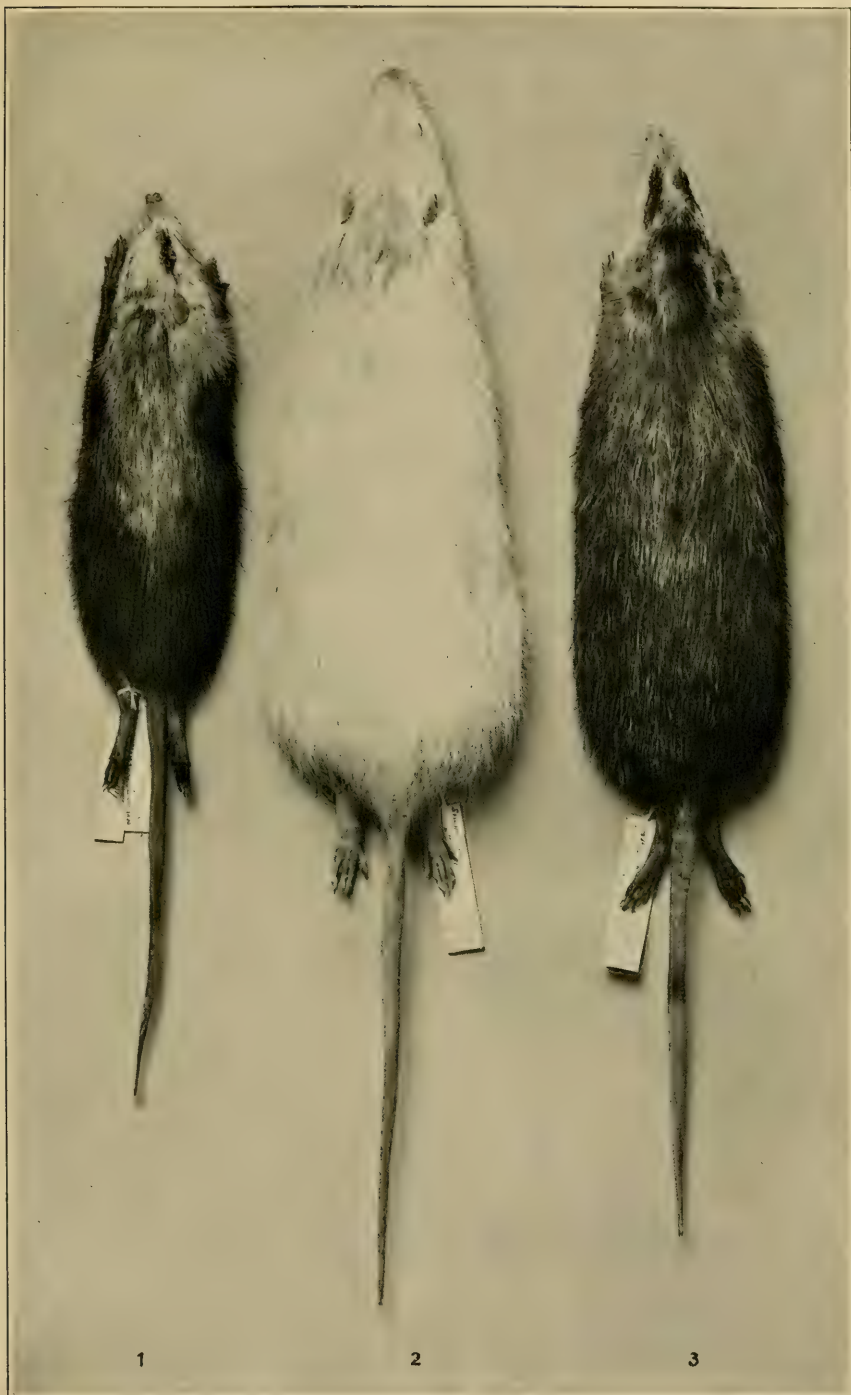
## PLATE 36 (twice natural size).

Skulls of *Hylomys suillus* (Müller and Schlegel), Cat. No. 124229, U.S.N.M., Tenasserim, Dr. W. L. Abbott, collector, and *Podogymnura truei* Mearns, Type, Cat. No. 125286, U.S.N.M., Mount Apo, Mindinao, Philippine Islands, Dr. E. A. Mearns, U. S. A., collector.

- FIG. 1. Right mandibular ramus of *Hylomys*.
2. Right mandibular ramus of *Podogymnura*.
3. Dorsal view of mandibular teeth of *Hylomys*.
4. Dorsal view of mandibular teeth of *Podogymnura*.
5. Palatal view of part of skull of *Hylomys*.
6. Palatal view of part of skull of *Podogymnura*.
7. Lateral view of facial portion of skull of *Podogymnura*.
8. Lateral view of facial portion of skull of *Hylomys*.

PLATE 37 (about  $\frac{1}{2}$  natural size).

- FIG. 1. External appearance of *Podogymnura truei* Mearns. Type, Cat. No. 125286, U.S.N.M., Mount Apo, Mindanao, Philippine Islands.
2. External appearance of *Hylomys suillus dorsalis* Thomas. Topotype, Cat. No. 124328, U.S.N.M., Mount Kinabalu, British North Borneo.

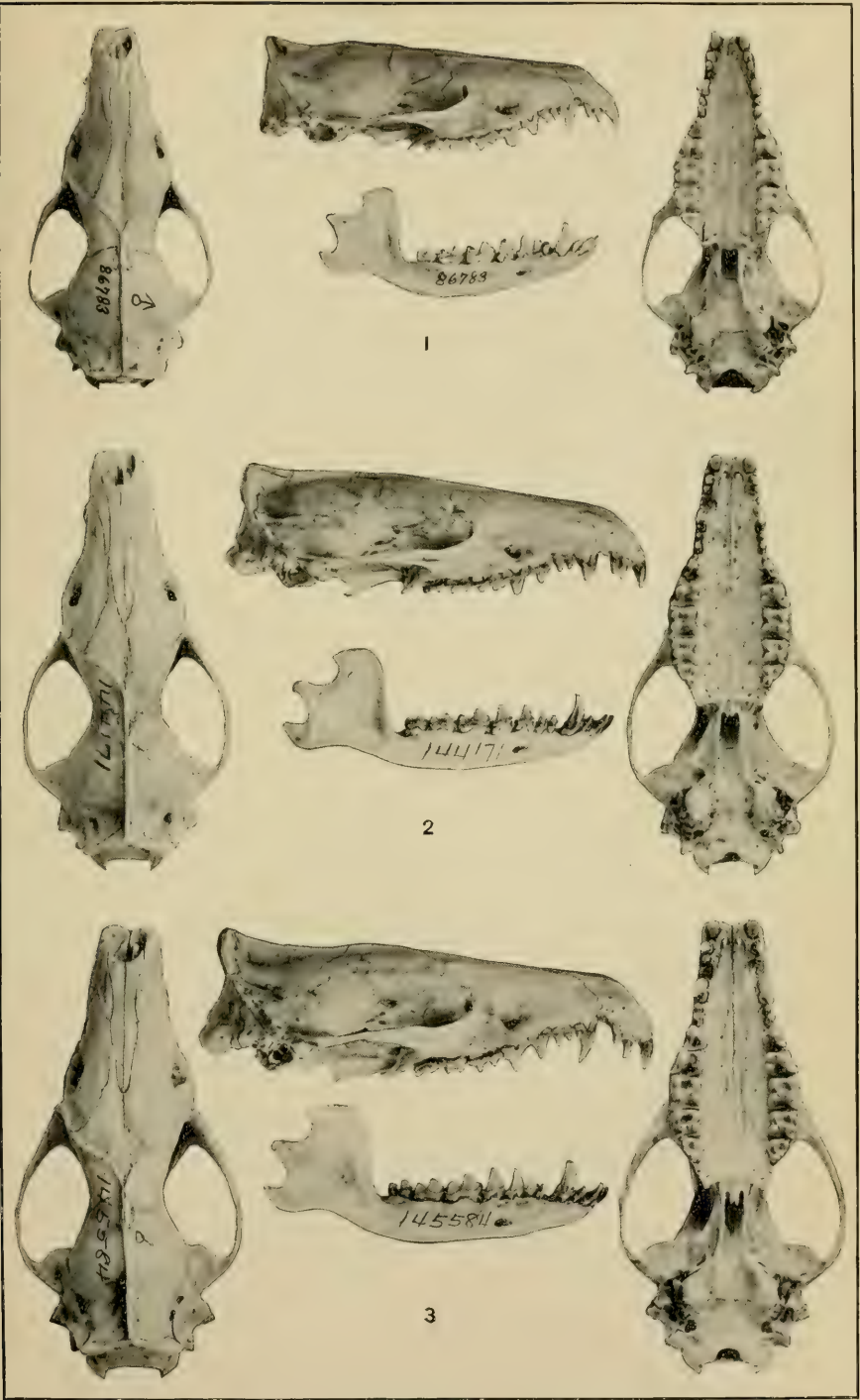


SKINS OF THE THREE FORMS OF *GYMNURA* (ABOUT ONE-FOURTH NATURAL SIZE).

FOR EXPLANATION OF PLATE SEE PAGE 456.



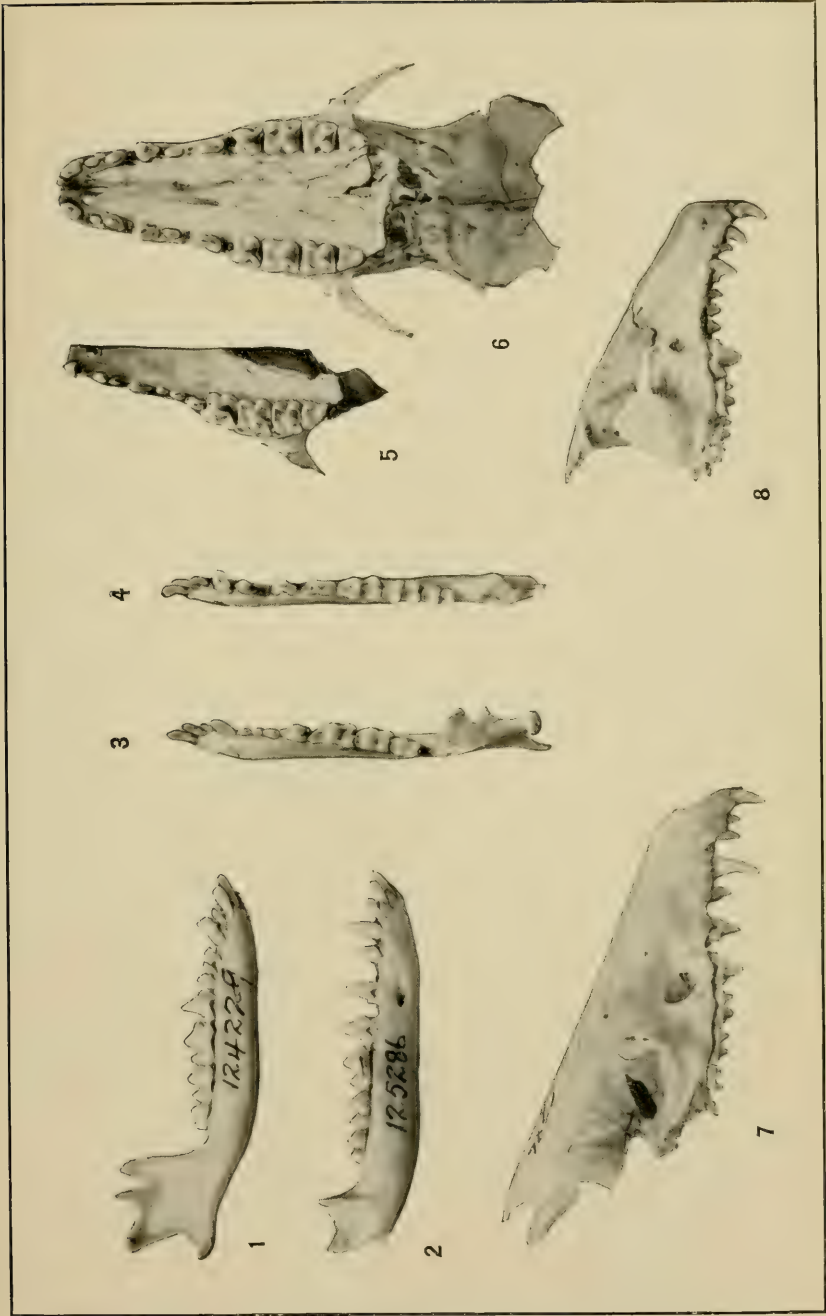




SKULLS OF THE THREE FORMS OF GYMNURA (TWO-THIRDS NATURAL SIZE).

FOR EXPLANATION OF PLATE SEE PAGE 456.



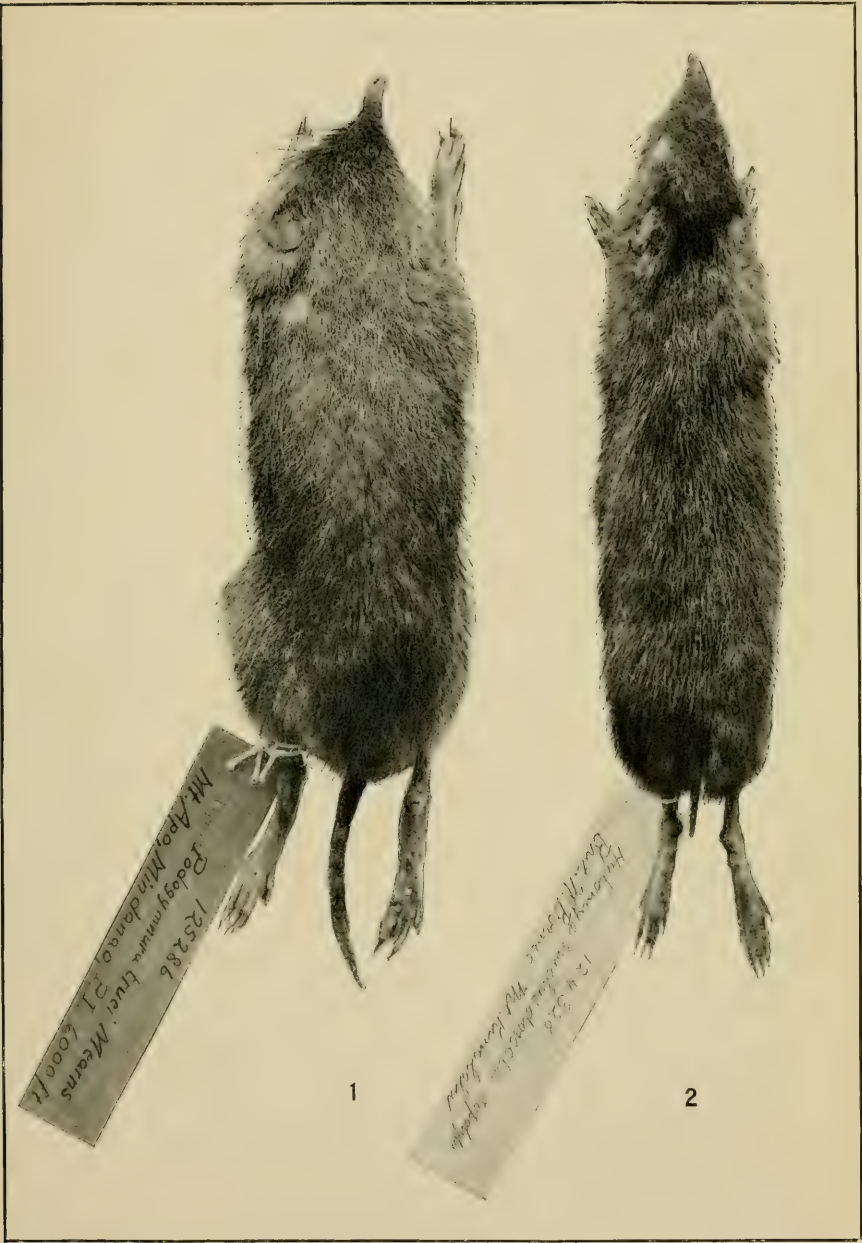


SKULLS OF THE GENERA *HYLOMYS* AND *PODOGYMNURA* (TWICE NATURAL SIZE).

FOR EXPLANATION OF PLATE SEE PAGE 456.







EXTERNAL APPEARANCE OF PODOGYMNURA AND HYLOMYS (ABOUT FIVE-SEVENTHS NATURAL SIZE).

FOR EXPLANATION OF PLATE SEE PAGE 456.



## DESCRIPTION OF A NEW SNAKE FROM PANAMA.

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By LEONHARD STEJNEGER,

*Curator, Division of Reptiles and Batrachians, U. S. National Museum.*

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Among a small lot of reptiles collected by Mr. Frank E. Read at Bocas del Toro there is a specimen of a little snake which appears to be undescribed. Bocas del Toro is situated on a small island at one of the entrances to the bay of Chiriqui, on the Atlantic side and near the western extremity of the Republic of Panama.

MESOPELTIS LONGIFRENIS, new species.

*Diagnosis.*—A small unpaired postmental in contact with anterior lower labial only; median dorsal scale row not enlarged; loreal three times as long as high, entering eye; no preocular; ventrals 165; subcaudals 98; supralabials 8.

*Habitat.*—Panama.

*Type-specimen.*—Cat. No. 38750, U.S.N.M.: Bocas del Toro, Republic of Panama; Frank E. Read, collector.

*Description of type-specimen.*—Body only moderately compressed and slender; tail at vent suddenly diminishing both in height and width; eye moderate, with vertical pupil; rostral small, triangular, as high as wide, scarcely visible from above; internasals small, their suture less than one-half that between the prefrontals, descending low on the side of the face and entering the orbit broadly; frontal longer than wide, longer than distance from tip of snout, shorter than the parietals but longer than the suture between them, wider than supraoculars; nasal undivided, with a horizontally oval nostril; loreal very long, three times as long as high, entering eye below prefrontal; no preocular; two postoculars, upper largest; temporals 1+2; supralabials 8, fourth, fifth, and sixth entering eye, sixth largest; mental small, followed by a small postmental separating the first pair of lower labials and also the mental from the anterior chin-shields; 8 lower labials, first five in contact with anterior chin-shield; anterior chin-shields large, followed by one on the right side and

two on the left; behind these a wide plate somewhat wider than the adjacent first ventral; 15 rows of smooth scales without pores, median row not sensibly larger than the others; 165 ventrals; anal single; subcaudals 98. Color (in alcohol) brownish gray with a median series of about 42 pale brown ocelli, edged with black, on the body, the last six descending to the ventrals so as to form transverse bands, many of the ocelli, especially anteriorly, divided medially, the halves more or less alternating; on the two or three outer scale rows a series of similar spots below the dorsal ones, each edged in front and behind by a blackish border, between which a whitish interval; tail above with about 17 alternating pale brown and brownish gray bands with a small whitish spot in the middle of the latter on the sides: head and nape dark brownish gray with indistinct marblings of pale brown and yellowish; third, fourth, and fifth labials marked with whitish; underside pale with dark brownish gray dots and spots which tend to form two parallel series on the ventrals.

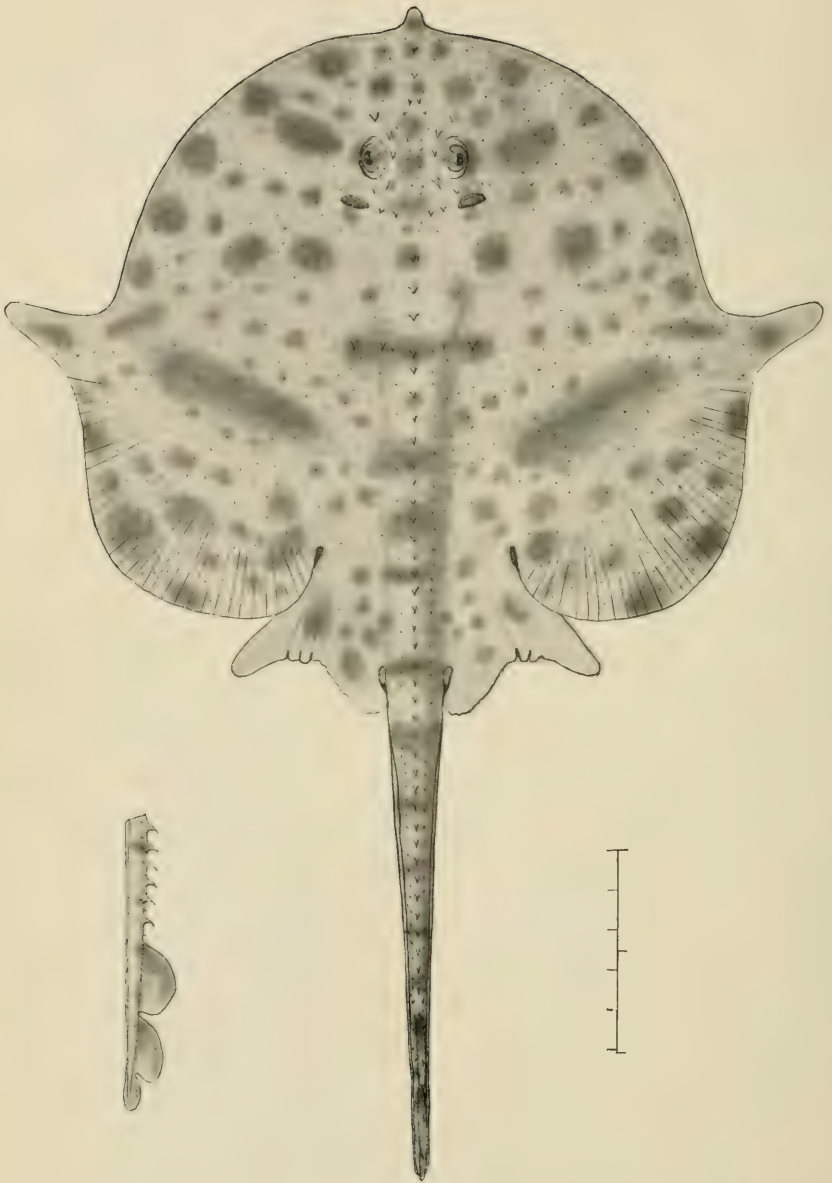
*Dimensions.*

Total length	mm. 488
Tip of snout to vent	335
Vent to tip of tail	153

*Remarks.*—The present species differs from *Mesopeltis dimidiatus* (Guenther) and *M. sanniolus* Cope in having a much smaller unpaired postmental which is only in contact with the first pair of lower labials, and in a longer snout with a much longer and lower loreal. In the coloration of the back and sides it resembles Cope's *Leptognathus argus* which, however, has a short snout and, moreover, possesses preoculars. From *M. sanniolus* it differs furthermore by having a larger number of subcaudals, and from *M. dimidiatus*, as well as from *L. argus*, by the much smaller number of ventrals.







DORSAL VIEW OF *DACTYLOBATUS ARMATUS* (ONE-HALF NATURAL SIZE).

FOR EXPLANATION OF PLATE SEE PAGE 459.

DESCRIPTION OF A NEW SKATE (DACTYLOBATUS ARMATUS) FROM DEEP WATER OFF THE SOUTHERN ATLANTIC COAST OF THE UNITED STATES.

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By BARTON A. BEAN AND ALFRED C. WEED,  
*Of the Division of Fishes, U. S. National Museum.*

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Among the fishes collected by the Bureau of Fisheries steamer *Albatross* in deep water off Charleston, South Carolina, during 1885 and 1886 were a male and female specimen of skate, closely allied to *Raja* but differing greatly from this genus in having the middle rays of the pectorals very much produced. This genus may be called *Dactylobatus* in allusion to the finger-like processes of the pectorals.

DACTYLOBATUS Bean and Weed, new genus.

Disk subcircular, not rhombic as in *Raja*; middle rays of the pectorals produced as a finger-like process on each side; dorsal surface armed with spines and prickles but apparently without the patch of differentiated spines near the outer edge of the pectorals that is found in the males of *Raja*; tail abruptly marked off from the disk as in *Raja*, not tapering gradually as in *Rhinobatus* and *Narcine*; tail armed with spines and prickles on the dorsal surface and with a rather wide dermal flap on each side; two dorsal fins near the end of the tail; a rudimentary caudal fin present.

*Type of genus.*—*Dactylobatus armatus*.

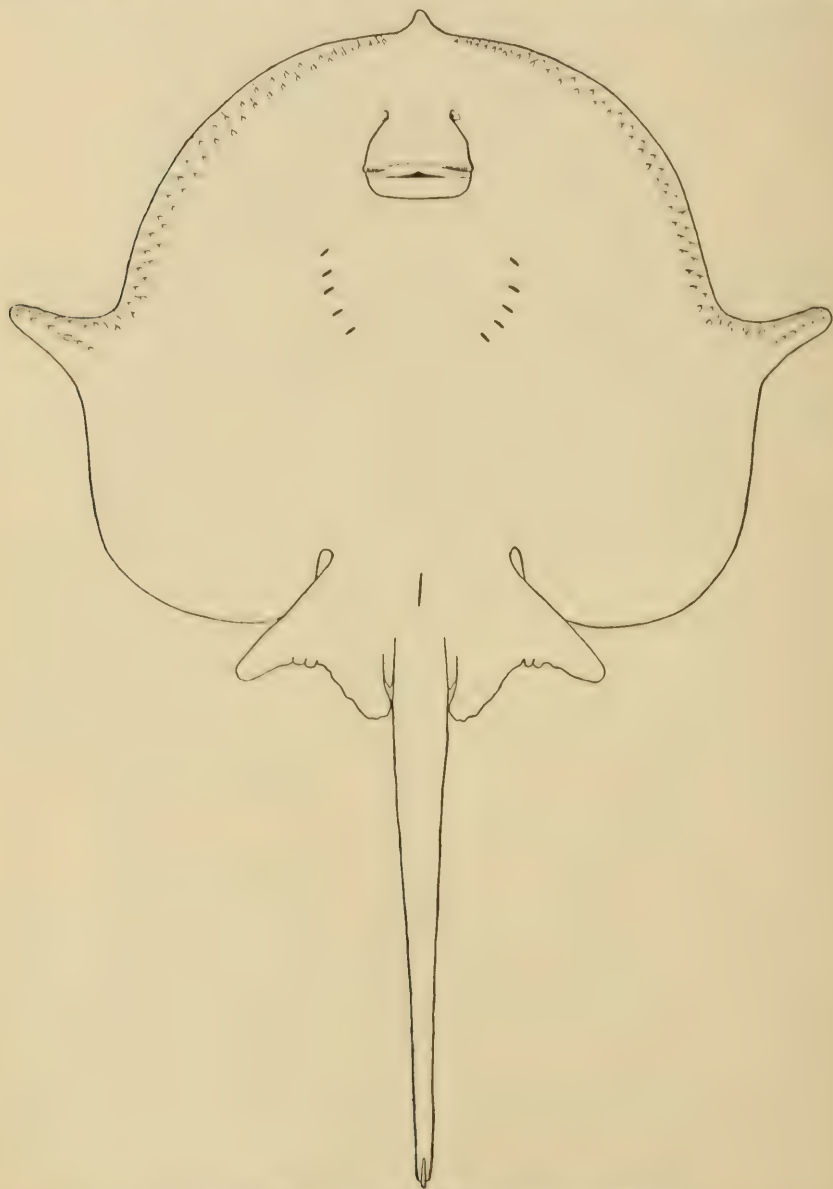
DACTYLOBATUS ARMATUS Bean and Weed, new species.

Disk nearly circular, with the snout slightly projecting and with about six or seven of the middle pectoral rays produced to form a finger-like or flap-like process, armed on the ventral surface with a double row of sharp, hooked spines having their points directed toward the meson. This armament is continued forward along the edges of the disk, nearly to the snout; middle line of back and tail with a single row of enlarged hooked spines with a row of smaller ones on each side of it. A single large blunt spine on each shoulder and a row of five on each orbital ridge; rest of the dorsal surface and the dorsal fins sparsely covered with fine prickles.

Color in alcohol, ashy with large black spots which coalesce to form blotches of various sizes and shapes; the belly white, clouded with

dark. Where what appears to be a layer of hardened mucus is removed, the color appears as a pinkish brown with dark brown spots.

Two specimens are known—a male, number 62914, from *Albatross* station 2624,  $32^{\circ} 36' N.$ ,  $77^{\circ} 29' 15'' W.$  at a depth of 258 fathoms,



OUTLINE OF VENTRAL SURFACE OF DACTYLOBATUS ARMATUS.

and a female, number 62915, from station 2666 or 2667, about  $31^{\circ} N.$  by  $80^{\circ} W.$ , at a depth of about 270 fathoms. The male was taken October 21, 1885, and the female May 5, 1886.



Table of measurements.

	Male.	Female.
	<i>Cm.</i>	<i>Cm.</i>
Total length.....	<i>a</i> 29.4	<i>b</i> 26.4
Extreme width.....	<i>c</i> 20.5	<i>d</i> 17.0
Snout to end of ventral fin.....	17.7	16.5
Snout to end of pectoral fin.....	15.3	14.3
Snout to line joining centers of pupils.....	3.7	3.5
Snout to line joining spiracles.....	4.9	4.5
Snout to line joining nostrils.....	2.6	2.2
Snout to line joining first gill slits.....	6.0	5.5
Snout to line joining last gill slits.....	8.0	7.0
Snout to center of mouth.....	4.1	4.0
Snout to vent.....	14.9	13.5
Snout to line joining ends of "fingers".....	7.5	6.5
Width of mouth.....	2.7	2.4
Width between centers of pupils.....	2.4	2.2
Width between spiracles.....	2.2	2.0
Width between nostrils.....	1.7	1.5
Width between first gill slits.....	4.5	4.2
Width between last gill slits.....	3.1	3.3
Fingers extend beyond line of disk about.....	2.5	2.5
Tail, measured from vent.....	14.5	12.9

$a$  11 $\frac{9}{16}$  inches.

$b$  10 $\frac{3}{4}$  inches.

$c$  8 $\frac{1}{16}$  inches.

$d$  6 $\frac{11}{16}$  inches.

This species is called *armatus* in allusion to the peculiar armament of the ventral surface.



A LIST OF BIRDS COLLECTED BY DR. PAUL BARTSCH  
IN THE PHILIPPINE ISLANDS, BORNEO, GUAM, AND  
MIDWAY ISLAND, WITH DESCRIPTIONS OF THREE  
NEW FORMS.

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By EDGAR ALEXANDER MEARNs,  
*Associate in Zoology, U. S. National Museum.*

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On the voyage of the United States Bureau of Fisheries steamer *Albatross* to the Philippine Islands Dr. Paul Bartsch accompanied that vessel as a representative of the United States National Museum, and made collections of birds whenever opportunity afforded, being assisted in this work by the regular staff of the *Albatross*.

Collections were thus made at Midway Island during November 7 and 8, 1907; at Guam Island, November 19 to 21, 1907; at Sandakan, Borneo, and vicinity, March 1 to 3, 1908; but by far the largest collection was gathered in the Philippine Islands, where many important gaps were filled in the United States National Museum series of birds. The following forms are here described as new to science: *Ramphaleyon capensis smithi* and *Pycnonotus goiavier suluensis* from the Philippines, and *Collocalia bartschi* from Guam.

The following-named Philippine species are new to the collection of the U. S. National Museum: *Loriculus bonapartei*, *Yungipicus ramsayi*, *Rhinomyias ocularis*, *Edoliosoma everetti*, *Pericrocotus marchesei*, *Anthreptes wigglesworthi* (female), and *Chibia suluensis*.

The collection also contained several species not previously received from the Philippine Islands.

BIRDS COLLECTED IN THE PHILIPPINE ISLANDS.

MEGAPODIUS CUMINGI Dillwyn.

Cat. No. 211299, adult. Taal Volcano, Batangas Province, Luzon, December 27, 1907.

GALLUS GALLUS (Linnæus).

Cat. No. 211300-1, male adults. Taal Volcano, Batangas Province, Luzon, December 27, 1907.

Cat. No. 211302, female adult. Taal Volcano, Batangas Province, Luzon, December 27, 1907.

**OSMOTRERON VERNANS** (Linnæus).

Cat. No. 211308, male adult. Taal Volcano, Batangas Province, Luzon, December 27, 1907.

**PHAPITRERON BREVIROSTRIS** Tweeddale.

Cat. No. 211309, male adult. Davao, southern Mindanao, May 17, 1908.

**MUSCADIVORES NUCHALIS** (Cabanis).

Cat. No. 211307, — adult. Port Binang, Laguna Province, Luzon, January 8, 1908.

Cat. No. 211306, male adult. Lapac Island, Sulu group, February 17, 1908.

**MUSCADIVORES ÆNEA** (Linnæus).

Cat. No. 211304, male adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211305, female adult. Dumurug Point, Masbate, April 18, 1908.

**MYRISTICIVORA BICOLOR** (Scopoli).

Cat. No. 211303, male adult. Lapac Island, Sulu group, February 17, 1908.

**MACROPYGIA TENUIROSTRIS** Bonaparte.

Cat. No. 211310, male adult. Taal Volcano, Batangas Province, Luzon, December 26, 1907.

**STREPTOPELIA DUSSUMIERI** (Temminck).

Cat. No. 211311, male immature. Taal Volcano, Batangas Province, Luzon, December 27, 1907.

**PUFFINUS LEUCOMELAS** (Temminck).

Cat. No. 211223, female adult. Near the Philippine Islands, latitude,  $13^{\circ}$   $12'$  N.; longitude,  $131^{\circ}$   $20'$  E., November 24, 1907.

**HYDROCHELIDON HYBRIDA** (Pallas).

Cat. No. 211264-6, female adults. Manila Harbor, Luzon Island, May 4, 1908.

**STERNA BERGII BOREOTIS** Bangs.

Cat. No. 211263, female adult. Batangas Bay, Luzon Island, June 7, 1903.

**OCHTHODROMUS GEOFFROYI** (Wagler).

Cat. No. 211283, female adult. Jolo, Sulu Island, March 7, 1908.

Cat. No. 211284, male adult. Tataan Island, Tawi Tawi group, February 19, 1908.

**ÆGIALITIS DUBIA** (Scopoli).

Cat. No. 211285, male immature. Majayjay, Laguna Province, Luzon, December 19, 1907.

Cat. No. 211286, female immature. Pansipit River, Batangas Province, Luzon, December 25, 1907.

Cat. No. 211287, male adult. Davao, southern Mindanao, May 17, 1908.

**ÆGIALITIS ALEXANDRINA** (Linnæus).

Cat. No. 211288-91, females. Jolo, Sulu Island, March 7, 1908.

**NUMENIUS VARIEGATUS** (Scopoli).

Cat. No. 211296, male adult. Davao, Mindanao, May 16, 1908.

**ACTITIS HYPOLEUCOS** (Linnæus).

Cat. No. 211292, female adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211293, — adult. Jolo, Sulu Island, March 7, 1908.

**GLOTTIS NEBULARIUS** (Gunnerus).

Cat. No. 211295, female adult. Davao, Mindanao, May 17, 1908.

**RHYACOPHILUS GLAREOLA** (Gmelin).

Tagal name: "Manunagtog."

Cat. No. 211294, male adult. Majayjay, Luzon, December 19, 1907.



**ORTHORHAMPHUS MAGNIROSTRIS** (Vieillot).

Cat. No. 211297, male adult. Tataan Island, Tawi Tawi group, February 19, 1908.

Cat. No. 211298, female adult. Tataan Island, Tawi Tawi group, February 19, 1908. "Eggs well developed."

The U. S. Bureau of Fisheries has recently sent us a third specimen collected by the *Albatross* Philippine Expedition:

Cat. No. 211631, — adult. Palau Island, off northeastern Luzon, November 18, 1908.

**PYRRHERODIAS MANILLENSIS** (Meyen).

Cat. No. 211270 (=15279 Mearns), female adult. Altitude 4,500 feet, near Baguio, Benguet Province, Luzon, July 6, 1907. Governor Pack asked Doctor Mearns to skin this bird for him. The governor subsequently gave the specimen to Dr. Paul Bartsch.

**DEMIEGRETTA SACRA** (Gmelin).

Cat. No. 211271, male adult. Dumurug Point, Masbate, April 18, 1908.

Cat. No. 211272, male adult. Capunuyugan Point, Mindanao, May 10, 1908.

Cat. No. 211273, female adult. Capunuyugan Point, Mindanao, May 10, 1908.

**NYCTICORAX MANILLENSIS** Vigors.

Cat. No. 211274, male adult. Pansipit River, Luzon, December 25, 1907.

Cat. No. 211275, female young. Pansipit River, Luzon, December 25, 1907.

**BUTORIDES JAVANICA** (Horsfield).

Cat. No. 211277, female young. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211278, male young. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211280, male adult. Silago River, Samar, April 12, 1908.

Cat. No. 211281, female adult. Silago River, Samar, April 12, 1908.

Cat. No. 211282, male adult. Baganga River, eastern Mindanao, May 13, 1908.

**BUBULCUS COROMANDUS** (Boddaert).

Cat. No. 211276, female adult. Baganga River, eastern Mindanao, May 13, 1908. Adult female in nuptial plumage.

**IXOBRYCHUS CINNAMOMEA** (Gmelin).

Cat. No. 211279, female immature. Pansipit River, Luzon, December 25, 1907.

**DENDROCYGNA ARCUATA** (Horsfield).

Cat. No. 211268, male adult. Davao River, southern Mindanao, May 16, 1908.

Cat. No. 211269, female adult. Davao River, southern Mindanao, May 16, 1908.

**ANHINGA MELANOGASTER** (Pennant).

Cat. No. 211267, female. Pansipit River, Luzon, December 27, 1907.

**SPILORNIS HOLOSPILUS** (Vigors).

Cat. No. 211313, male adult. Surigao River, northeastern Mindanao, May 8, 1908.

**PONTOAETUS LEUCOGASTER** (Gmelin).

Cat. No. 211312, male immature. Bongao Island, Tawi-tawi group, February 23, 1908.

**ELANUS HYPOLEUCUS** Gould.

Cat. No. 211314, male adult. Tacloban, Leyte, April 11, 1908.

Cat. No. 211315, male adult. Surigao River, northeastern Mindanao, May 8, 1908.

**CACATUA HAEMATUROPYGIA** (P. L. S. Müller).

Cat. No. 211318, male adult. Silago River, Samar, April 12, 1908.

Cat. No. 211316, male adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211317, female adult. Dumurug Point, Masbate, April 17, 1908.

Cat. No. 211319, female adult. Siasi Island, Sulu group, February 18, 1908.

**TANYGNATHUS LUCIONENSIS** (Linnaeus).

Cat. No. 211321-3, males. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211324, female. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211320, male. Romblon, Romblon Island, March 26, 1908.

Cat. No. 211325, male. Lapac Island, Sulu group, February 17, 1908.

**LORICULUS BONAPARTEI** Souancé.

Cat. No. 211326, female adult. Jolo, Sulu Island, March 7, 1908.

**EURYSTOMUS ORIENTALIS** (Linnaeus).

Cat. No. 211353, male adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211354, male adult. Silago River, Samar, April 11, 1908.

Cat. No. 211356, male adult. Capunuyugan Point, Mindanao, May 10, 1908.

Cat. No. 211355, female adult. Mati, eastern Mindanao, May 15, 1908.

**RAMPHALCYON CAPENSIS GIGANTEA** (Walden).

Cat. No. 211364, male adult. Baganga River, eastern Mindanao, May 13, 1908.

Cat. No. 211365, male adult. Bongao Island, Tawi-tawi group, February 23, 1908.

Cat. No. 211366, female adult. Bongao Island, Tawi-tawi group, February 23, 1908.

The typical Mindanao specimen is decidedly bluer—less greenish blue—on the upper surfaces than the pair from Bongao Island.

**RAMPHALCYON CAPENSIS SMITHI**, new subspecies.

**MASBATE STORK-BILLED KINGFISHER.**

*Type*.—Cat. No. 211363, U. S. N. M., adult male, collected by Dr. Paul Bartsch at Dumurug Point, Masbate Island, April 18, 1908.

*Characters*.—Intermediate in color between *R. c. gigantea* and *R. c. gouldi*. The largest Philippine form; head, buff; under parts, ochraceous-buff.

*Measurements of type* (adult male).—Wing, 157 mm.; tail, 96; exposed culmen, 80; tarsus, 17.

*Geographical range*.—Southeastern Luzon, Masbate, and others of the middle islands of the Philippines, where the ranges of *R. c. gigantea* and *R. c. gouldi* approach each other. There are several specimens of this form in the Menage collection, gathered by Messrs. Worcester and Bourns, now in the Bishop Museum at Honolulu. Named in honor of Dr. Hugh M. Smith, Deputy Commissioner of Fisheries and director of the Albatross Philippine expedition.

**ALCEDO BENGALENSIS** Gmelin.

Cat. No. 211383, female adult. Pansipit River, Luzon, December 25, 1907.

Cat. No. 211384, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211385, female immature. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211386, female adult. Montalbon, Luzon, January 1, 1908.

**HALCYON GULARIS** (Kuhl).

- Cat. No. 211367, female adult. Majayjay, Laguna Province, Luzon, December 18, 1907.  
 Cat. No. 211368, female adult. Santa Cruz, Laguna Province, Luzon, December 20, 1907.  
 Cat. No. 211369, male adult. Near San Fernando, Union Province, Luzon, March 16, 1908.  
 Cat. No. 211370, male adult. Silago River, Samar, April 12, 1908.

**HALCYON WINCHELLI** Sharpe.

- Cat. No. 211371, male adult. Papahag Island, Tawi-tawi group, February, 23, 1908.

**HALCYON CHLORIS** (Boddaert).

- Cat. No. 211372, female immature. Taal Volcano, Luzon, December 27, 1907.  
 Cat. No. 211373, male immature. Pansipit River, Luzon, January 18, 1908.  
 Cat. No. 211374, female immature. Pansipit River, Luzon, December 25, 1907.  
 Cat. No. 211375, female immature. Port Binang, Luzon, January 8, 1908.  
 Cat. No. 211376, male adult. Dumurug Point, Masbate, April 19, 1908.  
 Cat. No. 211377, male adult. Panabutan Bay, Mindanao, February 5, 1908.  
 Cat. No. 211378, female adult. Davao, Mindanao, May 17, 1908.  
 Cat. No. 211379-80, male adults. Lapac Island, Sulu group, February 17, 1908.  
 Cat. No. 211381, female adult. Bongao Island, Tawi-Tawi group, February 23, 1908.  
 Cat. No. 211382, male adult. Bongao Island, Tawi-Tawi group, February 23, 1908.

**PENELOPIDES PANINI** (Boddaert).

- Cat. No. 211390-1, male adults. Dumurug Point, Masbate, April 18, 1908.  
 Cat. No. 211392-3, male adults. Dumurug Point, Masbate, April 19, 1908.  
 Cat. No. 211394, female adult. Dumurug Point, Masbate, April 18, 1908.  
 Cat. No. 211395, female adult. Dumurug Point, Masbate, April 19, 1908.

**PENELOPIDES AFFINIS** Tweeddale.

- Cat. No. 211396, male adult. Capunuyugan Point, Mindanao, May 10, 1908.

**CRANORRHINUS LEUCOCEPHALUS** (Vieillot).

- Cat. No. 211387, male adult. Capunuyugan Point, Mindanao, May 10, 1908.  
 Cat. No. 211388-9, male adults. Mati, eastern Mindanao, May 15, 1908.

**MEROPS AMERICANUS** P. L. S. Müller.

- Cat. No. 211357, male adult. Dumurug Point, Masbate, April 19, 1908.

**MEROPS PHILIPPINUS** Linnæus.

- Cat. No. 211360, male adult. Naguillian, Union Province, March 15, 1908.  
 Cat. No. 211361, male adult. Near Naguillian, Union Province, March 16, 1908.  
 Cat. No. 211358, male adult. Pansipit River, Luzon, December 25, 1907.  
 Cat. No. 211359, male adult. Pansipit River, Luzon, January 8, 1908.  
 Cat. No. 211362, male adult. Bongao Island, Tawi-Tawi group, February 23, 1908.

**HEMIPROCNE COMATA** (Temminck).

- Cat. No. 211351, female adult. Silago River, Samar, April 12, 1908.

Mindanao and Samar islands are included in the range of *Hemiprocne comata comata*. The specimens of *H. c. major* in the U. S. National Museum are from Luzon and Panay islands.

**COLLOCALIA TROGLODYTES** Gray.

Cat. No. 211346, male adult. Near Majayjay, Luzon, December 19, 1907.

Cat. No. 211347, adult. Near Majayjay, Luzon, December 19, 1907.

**COLLOCALIA MARGINATA** Salvadori.

Cat. No. 211348, male adult. Near Majayjay, Luzon, December 19, 1907.

Cat. No. 211349, female adult. Montalbon, Luzon, January 1, 1908.

Cat. No. 211350, female adult. Capunuyugan Point, Mindanao, May 10, 1908.

**PYROTROGON ARDENS** (Temminck).

Cat. No. 211352, male immature. Tacloban, Leyte, April 11, 1908.

**EUDYNAMIS MINDANENSIS** (Linnæus).

Cat. No. 211328, male adult. Dumurug Point, Masbate, April 17, 1908.

Cat. No. 211329, male adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211330, female adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211331, female immature. Dumurug Point, Masbate, April 17, 1908.

**CENTROPUS VIRIDIS** (Scopoli).

Cat. No. 211338, male immature. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211332, male adult. Dumurug Point, Masbate, April 18, 1908.

Cat. No. 211333, female adult. Dumurug Point, Masbate, April 18, 1908.

Cat. No. 211335-7, male adults. Baganga River, eastern Mindanao, May 13, 1908.

Cat. No. 211334, female adult. Mati, eastern Mindanao, May 15, 1908.

**CENTROPUS JAVANICUS** (Dumont).

Cat. No. 211339, male adult. Tacloban, Leyte, April 11, 1908.

**DASYLOPHUS SUPERCILIOSUS** (Cuvier).

Cat. No. 211327, male adult. Magdalena, Laguna Province, Luzon, December 18, 1907.

**XANTHOLÆMA HÆMACEPHALUM** (P. L. S. Müller).

Cat. No. 211345, male adult. Taal Volcano, Luzon, January 18, 1908.

**YUNGIPICUS RAMSAYI** Hargitt.

Cat. No. 211344, male adult. Papahag Island, off Tawi Tawi, February 23, 1908.

**YUNGIPICUS VALIDIROSTRIS** (Blyth).

Cat. No. 211342, male adult. Magdalena, Laguna Province, Luzon, December 20, 1907.

Cat. No. 211343, female adult. Magdalena, Laguna Province, Luzon, December 20, 1907.

Cat. No. 211341, male adult. Taal Volcano, Luzon, December 27, 1907.

**CHRYSOCOLAPTES LUCIDUS MONTANUS** Grant.

Cat. No. 211340, female adult. Mati, eastern Mindanao, May 15, 1908. An extreme example of *montanus*. This is a species of eastern Mindanao, intergrading with *lucidus* at Pantar, western Mindanao, instead of being a mountain form.

**HIRUNDO GUTTURALIS** Scopoli.

Cat. No. 211447, female adult. Santa Cruz, Laguna Province, Luzon, December —, 1907.

Cat. No. 211448, female immature. Majayjay, Luzon, December 19, 1907.

**HIRUNDO JAVANICA** Sparrman.

Cat. No. 211449, female adult. Romblon, Romblon Island, March 26, 1908.



**CYORNIS PHILIPPINENSIS** Sharpe.

Cat. No. 211500, male adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211501, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211502, female adult. Taal Volcano, Luzon, December 27, 1907.

**MUSCICAPULA WESTERMANNI** Sharpe.

Cat. No. 211517-8, female adults. Baguio, Benguet Province, Luzon, March 13, 1908.

**GERYGONE SIMPLEX** Cabanis.

Cat. No. 211503, male adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211504, female adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211505-6, female adults. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211507-10, adults. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211511, adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211512, male adult. Naguillian, Union Province, Luzon, March 15, 1908.

**GERYGONE RHIZOPHORÆ** Mearns.

Cat. No. 211513, female adult. Tataan Island, Tawi-tawi group, February 19, 1908. This specimen is doubtfully referred to this species on account of its darker coloration and larger size than *Gerygone simplex*. The sides of the head are nearly as dark as in *G. rhizophoræ* from Mindanao, and, like it, the crissum is pale and the under tail-coverts white; but the upper parts are much paler, and the bill smaller than in typical *rhizophoræ*.

**HYPOTHYMIS AZUREA** (Boddaert).

Cat. No. 211514, female adult. Port Binang, Luzon, January 9, 1908.

Cat. No. 211515, male adult. Capunuyugan Point, Mindanao, May 10, 1908.

Cat. No. 211516, male adult. Baganga River, Mindanao, May 13, 1908.

**RHIPIDURA CYANICEPS** (Cassin).

Cat. No. 211493, male adult. Olongapo, Luzon, January 8, 1908.

Cat. No. 211494, "female?" adult. Olongapo, Luzon, January 8, 1908.

**RHIPIDURA NIGRITORQUIS** Vigors.

Cat. No. 211495-6, male adults. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211497-8, female adults. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211499, male adult. Tataan Island, Tawi-tawi group, February 20, 1908.

**RHINOMYIAS OCULARIS** Bourns and Worcester.

An alcoholic specimen, taken on Pangamian Island, Sulu group, February 13, 1908, measures as follows: Length, 595 mm.; wing, 77; tail, 63; tarsus, 22.5; middle toe with claw, 18.

**ARTAMIDES KOCHI** Kutter.

Cat. No. 211408, male adult. Silago River, Samar, April 12, 1908.

**ARTAMIDES PANAYENSIS** Steere.

Cat. No. 211406, male adult. Dumurug Point, Masbate, April 18, 1908.

Cat. No. 211407, female adult. Cataingan Bay, Masbate, April 17, 1908.

**EDOLIOSOMA EVERETTI** Sharpe.

Cat. No. 211409, male adult. Lapac Island, Sulu group, February 17, 1908.

**PERICROCOTUS MARCHESÆ** Guillemard.

Cat. No. 211410, female adult. Jolo, Sulu Island, March 7, 1908.

**LALAGE NIGER** (Forster).

Cat. No. 211411, male adult. Pansipit River, Luzon, December 25, 1907.

Cat. No. 211412-4, male adults. Naguillian, Union Province, Luzon, March 16, 1908.

Cat. No. 211415, female adult. Naguillian, Union Province, Luzon, March 16, 1908.

Cat. No. 211416, male adult. Dumurug Point, Masbate, April 19, 1908.

**IOLE EVERETTI** Tweeddale.

Cat. No. 211462, male adult. Capmuyupugan Point, Mindanao, May 10, 1908.

**IOLE GULARIS** (Pucheran).

Cat. No. 211464, male adult. Montalbon, Luzon, January 8, 1908.

Cat. No. 211465, male adult. Montalbon, Luzon, January 1, 1908.

Cat. No. 211466, no label—adult. (Montalbon, Luzon, January 1, 1908?)

Cat. No. 211467, male adult. Port Binang, Luzon, January 8, 1908.

Cat. No. 211469, female adult. Tacloban, Leyte, April 11, 1908.

**IOLE GUIMARASENSIS** Steere.

Cat. No. 211468, male? Dumurug Point, Masbate, April 17, 1908.

**IOLE CINEREICEPS** Bourns and Worcester.

Cat. No. 211463, female adult. Romblon, Romblon Island, March 25, 1908.

**POLIOLOPHUS UROSTICTUS** (Salvadori).

Cat. No. 211479, male adult. Baganga River, eastern Mindanao, May 13, 1908.

Cat. No. 211480, female adult. Baganga River, eastern Mindanao, May 13, 1908.

**PYCNONOTUS GOIAVIER GOIAVIER** (Scopoli).

Cat. No. 211470, male adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211471, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211472-3, female adults. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211474, male adult. Port Dupon, Leyte, May 7, 1908.

**PYCNONOTUS GOIAVIER SULUENSIS** new subspecies.**SULU GUAVA BULBUL.**

*Type*.—Cat. No. 211475, U.S.N.M., adult male from Jolo, Sulu Island, Philippines, collected March 7, 1908, by Dr. Paul Bartsch.

*Characters*.—Similar to the Luzon Guava Bulbul (*Pycnonotus goiavier goiavier*), but smaller, with relatively shorter tail, broader supraorbital white stripes, and a paler auricular patch.

*Comparative measurements.*

Name.	No. of specimens.	Sex.	Locality.	Wing.	Tail.	Culmen (chord).	Tarsus.
				mm.	mm.	mm.	mm.
<i>Pycnonotus goiavier goiavier</i> ...	10	Male.....	Luzon Island.....	84	88	15.6	20.8
<i>Pycnonotus goiavier suluensis</i> ...	7	do.....	Mindanao Island...	80.7	81.1	15.3	19.9
Do.....	1	do.....	Basilan Island.....	83	86	16	21
Do.....	3	do.....	Sulu Island.....	81.7	82	15.8	19.3
<i>Pycnonotus goiavier goiavier</i> ...	6	Female.....	Luzon Island.....	80.3	84.5	14.7	20.3
<i>Pycnonotus goiavier suluensis</i> ...	6	do.....	Mindanao Island...	79	79.3	14.8	19.1
Do.....	1	do.....	Sulu Island.....	77	85	15.5	18.5

The Philippine forms of *Pycnonotus goiavier* are distinguishable from *P. analis* (Horsfield) by their smaller size and considerable color differences.

*Material examined.*—Twenty-three skins of *Pycnonotus goiavier goiavier* from the northern Philippine islands of Luzon, Mindoro, Panay, Samar, and Leyte; 20 skins from the southern Philippine islands of Mindanao, Basilan, and Sulu.

**PYCNONOTUS GOIAVIER SULUENSIS.**

Cat. No. 211475, male adult. Jolo, Sulu Island, March 7, 1908. Type.

Cat. No. 211476-7, male adults. Jolo, Sulu Island, March 7, 1908.

Cat. No. 211478, female adult. Jolo, Sulu Island, March 7, 1908.

**PETROPHILA MANILLENSIS (Forster).**

Cat. No. 211618, male adult. Twin Peaks, Benguet wagon road, Luzon, March 13, 1908.

Cat. No. 211619-20, females, immature. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211614, female adult. Majayjay, Luzon, December 20, 1907.

Cat. No. 211615, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211616, female adult. Summit of Taal Volcano, Luzon, January 18, 1908.

Cat. No. 211617, female, immature. Port Binang, Luzon, January 8, 1908.

**COPSYCHUS MINDANENSIS (Gmelin).**

Cat. No. 211610, male adult. Between Magdalena and Majayjay, Luzon, December 18, 1907.

Cat. No. 211611, female adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211612, male, immature. Romblon Island, March 26, 1908.

Cat. No. 211613, female adult. Lapac Island, Sulu group, February 17, 1908.

**PRATINCOLA CAPRATA (Linnaeus).**

Cat. No. 211519, male adult. Pansipit River, Luzon, December 25, 1907.

Cat. No. 211520, male adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211521-2, male adults. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211523-4, female adults. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211525, female adult. Baguio, Benguet Province, Luzon, March 13, 1908.

**ORTHOTOMUS FRONTALIS Sharpe.**

Cat. No. 211482, male adult. Capunuyugan Point, Mindanao, May 10, 1908.

**ORTHOTOMUS RUFICEPS (Lesson).**

Cat. No. 211483, male adult. Sitanki Island, February 26, 1908.

Cat. No. 211484, female adult. Sitanki Island, February 26, 1908.

**CISTICOLA CISTICOLA (Temminck).**

Cat. No. 211485, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211486, male adult. Pozorrubio, Benguet Wagon Road, Luzon, March 12, 1908.

Cat. No. 211487-8, male adults. Near San Fernando, Union Province, Luzon, March 16, 1908.

Cat. No. 211489, female adult. Near San Fernando, Union Province, Luzon, March 16, 1908.

Cat. No. 211490, — adult. Lemery, Batangas Province, Luzon, January 19, 1908.

Cat. No. 211492, female adult. Jolo, Sulu Island, March 7, 1908.

**CISTICOLA EXILIS (Vigors and Horsfield).**

Cat. No. 211491, male adult. Tacloban, Leyte, April 11, 1908.

**MEGALURUS PALUSTRIS** Horsfield.

Cat. No. 211481, female adult. Near Naguillian, Union Province, Luzon, March 15, 1908.

**ACANTHOPNEUSTE BOREALIS** (Blasius).

Cat. No. 211605, female adult. Between Magdalena and Majayjay, Luzon, December 18, 1907.

Cat. No. 211606, female adult. Pansipit River, Luzon, December 25, 1907.

Cat. No. 211607, female adult. Pozorrubio, Luzon, March 12, 1908.

Cat. No. 211608, male adult. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211609, female adult. Baguio, Benguet Province, Luzon, March 13, 1908.

**ARTAMUS LEUCORYNCHUS** (Linnæus).

Cat. No. 211397-S, male adults. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211399, female adult. Taal Volcano, Luzon, January 18, 1908.

Cat. No. 211400, female adult. Majayjay, Luzon, December 19, 1907.

Cat. No. 211401, female adult. Port Dupon, Leyte, May 7, 1908.

Cat. No. 211402, female adult. Jolo, Sulu Island, March 7, 1908.

Cat. No. 211403, male adult. Papahag Island, Tawi Tawi group, February 23, 1908.

Cat. No. 211404, female adult. Papahag Island, Tawi Tawi group, February 23, 1908.

Cat. No. 211405, — adult. Papahag Island, Tawi Tawi group, February 23, 1908.

**CEPHALOPHONEUS NASUTUS** (Scopoli).

Cat. No. 211435-6, female adults. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211437, male adult. Naguillian, Union Province, Luzon, March 15, 1908.

**OTOMELA LUCIONENSIS** (Linnæus).

Cat. No. 211438, female adult. Near Santa Cruz, Luzon, December 18, 1907.

Cat. No. 211439-40, males, immature. Magdalena, Luzon, December 20, 1907.

Cat. No. 211441, female immature. Pansipit River, Luzon, December 25, 1907.

Cat. No. 211442, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211443, male adult. Olongapo, Luzon, January 8, 1908.

Cat. No. 211444, male adult. San Fernando, Union Province, Luzon, March 16, 1908.

Cat. No. 211445, male adult. Tacloban, Leyte, April 11, 1908.

**HYLOTERPE ALBIVENTRIS** Grant.

Cat. No. 211446, male adult. Sablan, Benguet Province, Luzon, March 15, 1908.

**PARDALIPARUS ELEGANS** (Lesson).

Cat. No. 211597-9, male adults. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211600-1, female adults. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211602, female adult. Near Sablan, Benguet Province, Luzon, March 15, 1908.



**CALLISITTA MESOLEUCA** (Grant).

Cat. No. 211603, male adult. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211604, female adult. Baguio, Benguet Province, Luzon, March 13, 1908.

**ZOSTEROPS BASILANICA** Steere.

Cat. No. 211530, male adult. Papahag Island, Tawi Tawi group, February 23, 1908.

**ZOSTEROPS MEYENI** Bonaparte.

Cat. No. 211526, male adult. Taal Volcano, Luzon, December 26, 1907.

**ZOSTEROPS WHITEHEADI** Hartert.

Cat. No. 211527-9, female adults. Baguio, Benguet Province, Luzon, March 13, 1908.

**DICÆUM PAPUENSE** (Gmelin).

Cat. No. 211533, male adult. Basiao Island, off Samar, April 16, 1908.

Cat. No. 211534, male immature. Basiao Island, off Samar, April 16, 1908.

**DICÆUM PYGMÆUM** (Kittlitz).

Cat. No. 211531, male adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211532, female adult. Dumurug Point, Masbate, April 19, 1908.

**LEPTOCOMA SPERATA** (Linnæus).

Cat. No. 211537-41, male adults. Basiao Island, off Samar, April 16, 1908.

Cat. No. 211542-4, female adults. Basiao Island, off Samar, April 16, 1908.

Cat. No. 211545, female adult. Silago River, Samar, April 12, 1908.

**CYRTOSTOMUS JUGULARIS JUGULARIS** (Linnæus).

Cat. No. 211546, female adult. Between Magdalena and Majayjay, Luzon, December 18, 1907.

Cat. No. 211547, male adult. Santa Cruz, Luzon, December 20, 1907.

Cat. No. 211548, female adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211549, female adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211550, male adult. Pansipit River, Luzon, January 18, 1908.

Cat. No. 211551, male adult. Naguillian, Union Province, Luzon, March 15, 1908.

Cat. No. 211552, male adult. Romblon, Romblon Island, Luzon, March 25, 1908.

Cat. No. 211553-4, males young. Dumurug Point, Masbate, April 17, 1908.

Cat. No. 211555, male young. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211556-60, female adults. Basiao Island, off Samar, April 16, 1908.

**CYRTOSTOMUS JUGULARIS WOODI** Mearns.

Cat. No. 211561-2, male adults. Jolo, Sulu Island, March 7, 1908.

Cat. No. 211563, female adult. Jolo, Sulu Island, March 7, 1908.

Cat. No. 211564, male adult. Sitanki Island, February 26, 1908.

Cat. No. 211565-6, female adults. Sitanki Island, February 26, 1908.

Cat. No. 211567, male immature. Papahag Island, Tawi Tawi group, February 23, 1908.

Cat. No. 211568-9, male adults. Papahag Island, Tawi Tawi group, February 23, 1908.

Cat. No. 211570-1, female adults. Papahag Island, Tawi Tawi group, February 23, 1908.

There is also a female alcoholic specimen taken on Pangamian Island, Sulu group, February 13, 1908.

**ANTHREPTES MALACCENSIS** (Scopoli).

Cat. No. 211536, female adult. Sitanki Island, February 26, 1908.

**ANTHREPTES WIGLESWORTHII** Hartert.

Cat. No. 211535, female adult. Jolo, Sulu Island, March 7, 1908. This is a topotype. An adult male specimen from Pangamian Island, Sulu group, taken February 13, 1908, was also received in alcohol.

**MOTACILLA OCULARIS** Swinhoe.

Cat. No. 211451, female adult. Taal Volcano, Luzon, December 26, 1907.

**MOTACILLA BOARULA MELANOPE** (Pallas).

Cat. No. 211452, female adult. Majayjay, Luzon, December 18, 1907.

Cat. No. 211453, female adult. Majayjay, Luzon, December 19, 1907.

**ANTHUS HODGSONI** Richmond.

Cat. No. 211456-7, male adults. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211458-9, female adults. Baguio, Benguet Province, Luzon, March 13, 1908.

Cat. No. 211460-1, female adults. Near Sablan, Benguet Province, Luzon, March 15, 1908.

**ANTHUS RUFULUS** Vieillot.

Cat. No. 211454, female adult. Magdalena, Luzon, December 20, 1907.

Cat. No. 211455, male adult. Pansipit River, Luzon, December 25, 1907.

**ALAUDEA WATTERSI** Swinhoe.

Cat. No. 211450, — adult. Magdalena, Luzon, December 20, 1907.

**MUNIA ORYZIVORA** (Linnæus).

Cat. No. 211621, male young. Pozorrubio, Benguet Road, Luzon, March 12, 1908.

**MUNIA JAGORI** Martens.

Cat. No. 211623-4, male adults. Tacloban, Leyte, April 11, 1908.

Cat. No. 211625, female immature. Tacloban, Leyte, April 11, 1908.

Cat. No. 211626, male adult. Jolo, Sulu Island, February 17, 1908.

**MUNIA CABANISI** Sharpe.

Cat. No. 211627, male adult. Pozorrubio, Benguet Road, Luzon, March 12, 1908.

Cat. No. 211628, female adult. Pozorrubio, Benguet Road, Luzon, March 12, 1908.

Cat. No. 211629, female adult. Nagnuillian, Union Province, Luzon, March 15, 1908.

Cat. No. 211622, female, immature. Nagnuillian, Union Province, Luzon, March 15, 1908.

**ORIOLEUS CHINENSIS** Linnæus.

Cat. No. 211427, male adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211428, female adult. Taal Volcano, Luzon, December 26, 1907.

Cat. No. 211429, — immature. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211430, male adult. Nagnuillian, Union Province, Luzon, March 15, 1908.

Cat. No. 211431, male adult. Mati, southeastern Mindanao, May 15, 1908.

There is also an adult alcoholic specimen from Pangamian Island, Sulu group, taken February 13, 1906.

**DICRURUS BALICASSIUS** (Linnæus).

Cat. No. 211433, — adult. Without a label, but said by Doctor Bartsch to have been taken on the Pansipit River, Luzon.

**CHIBIA SULUENSIS** (Hartert).

Cat. No. 211432, male adult. Lapac Island, off Siasi Island, February 17, 1908. Measurements of skin: Length, 284 mm.; wing, 148; tail, 143; culmen, 35; tarsus, 25.

**ÆTHIOPSAR CRISTATELLUS** (Gmelin).

Cat. No. 211424, female adult. Taal Volcano, Luzon, December 27, 1907.

Cat. No. 211425, male adult. Pansipit River, Luzon, December 27, 1907.

**SARCOPS CALVUS** (Linnaeus).*Sarcops lowi* SHARPE, Trans. Linn. Soc., 1877 (Sibutu Island).

Cat. No. 211419, male adult. Papahag Island, Tawi Tawi group, February 23, 1908.

**SARCOPS CALVUS MELANONOTUS** Grant.

Cat. No. 211417, male adult. Dumurug Point, Masbate, April 19, 1908.

Cat. No. 211418, male adult. Tacloban, Leyte, April 11, 1908.

**LAMPROCORAX PANAYENSIS** (Scopoli).

Cat. No. 211420, female adult. Taal Volcano, Luzon, January 18, 1908.

Cat. No. 211426, male adult. Taal Volcano, Luzon, January 18, 1908.

Cat. No. 211421, male adult. Pansipit River, Luzon, January 18, 1908.

Cat. No. 211422, female adult. Dumurug Point, Masbate, April 17, 1908.

Cat. No. 211423, male adult. Papahag Island, Tawi Tawi group, February 23, 1908.

**CORONE PHILIPPINA** (Bonaparte).

Cat. No. 211434, male adult. Bongao Island, Tawi Tawi group, February 23, 1908.

## BIRDS COLLECTED IN BORNEO.

**HIRUNDO JAVANICA** Sparrman.

Cat. No. 211581, female adult. Sandakan, Borneo, March 2, 1908.

**PYCNONOTUS PLUMOSUS** Blyth.

Cat. No. 211573-4, female adults. Sandakan, Borneo, March 3, 1908.

**PYCNONOTUS SIMPLEX** Lesson.

Cat. No. 211575, male adult. Sandakan, Borneo, March 3, 1908. This appears to be one of the white-eyed forms of *P. simplex* mentioned by Doctor Richmond, in the Proceedings of the United States National Museum, XXVI, 1903, page 506; but the color of the iris was not noted by Doctor Bartsch.

**COPSYCHUS NIGER** Wardlaw Ramsay.

Cat. No. 211572, male adult. Sandakan, Borneo, March 3, 1908.

**ÆGITHINA VIRIDIS** (Bonaparte).

Cat. No. 211576, male adult. Po Bui Island, off Sandakan, Borneo, March 1, 1908.

Cat. No. 211577, male immature. Sandakan, northeastern Borneo, March 3, 1908.

**ANTHREPTES MALACCENSIS** (Scopoli).

Cat. No. 211582-5, male adults. Sandakan, Borneo, March 3, 1908.

Cat. No. 211586, female adult. Sandakan, Borneo, March 3, 1908.

Cat. No. 211587-92, male adults. Po Bui Island, off Sandakan, Borneo, March 1, 1908.

Cat. No. 211593-6, female adults. Po Bui Island, off Sandakan, Borneo, March 1, 1908.

**UROLONCHA FUSCANS** (Cassin).

Cat. No. 211578, male adult. Sandakan, Borneo, March 3, 1908.

Cat. No. 211579-80, female adults. Sandakan, Borneo, March 3, 1908.

## BIRDS COLLECTED AT GUAM ISLAND.

HALCYON CINNAMOMINUS Wm. Swainson.

Cat. No. 211254, female adult. Guam, November 19, 1907.

COLLOCALIA BARTSCHI, new species.

GUAM ISLAND SWIFTLET.

*Type*.—No. 211255, U.S.N.M. Adult female, collected on the island of Guam, Pacific Ocean, November 20, 1907, by Dr. Paul Bartsch.

*Characters*.—Most closely related to *Collocalia unicolor amelis* Oberholser, described from specimens taken in the Benguet Highlands of Luzon, Philippine Islands. Its naked tarsus and much paler coloration at once separate it from *Collocalia fuciphaga*; and the absence of a whitish band across the rump distinguishes it from members of the *Collocalia francica* group.

An adult male specimen (Cat. No. 200566, U.S.N.M.) of this species which I collected on Guam Island, July 20, 1905, is labeled "*Collocalia u. amelis*" in Mr. Oberholser's handwriting. Although Oberholser mentioned this specimen under *Collocalia unicolor amelis*, and included the island of Guam in the area of distribution of that form in his "Monograph of the Genus *Collocalia*," published in the Proceedings of the Academy of Natural Sciences of Philadelphia, pp. 193 and 194, issued July 26, 1906, he did not include it in the table of measurements which concludes the description, which circumstance suggests that its small size led him to consider its identity with *amelis* doubtful.

The wing is shorter than in *Collocalia u. amelis* while the tail is, relatively, a little longer, with the tail-feathers and upper tail-coverts much broader. The color differs from *amelis* in being paler on the hind-neck and sides of rump, the back a slightly paler and warmer brown, and the under parts decidedly paler, becoming almost silvery whitish on the chest.

This new species is named in honor of Dr. Paul Bartsch in recognition of this important contribution of birds to the collection of the U. S. National Museum, made in connection with the operations of the *Albatross* Philippine Expedition.

The following table gives comparative measurements:

No. of specimens.	Sex.	Name.	Locality.	Wing.	Tail.	Exposed culmen.	Tarsus.
				mm.	mm.	mm.	mm.
1	Male.....	<i>Collocalia bartschi</i> .....	Guam Id.....	108	53	3.9	8.8
1	Female.....	<i>Collocalia bartschi</i> .....	Guam Id.....	108	53	3.9	8.6
1	(?)	<i>Collocalia unicolor unicolor</i> .....	Ceylon.....	120	55	4.5	10
1	(?)	<i>Collocalia unicolor unicolor</i> .....	Ceylon.....	116	54	4	9.5
6	Male.....	<i>Collocalia unicolor amelis</i> .....	Benguet Prov., Luzon Id., P. I.	116	50	4.8	9.9
6	Female....	<i>Collocalia unicolor amelis</i> .....	Benguet Prov., Luzon Id., P. I.	116	50	5	10



**RHIPIDURA URANIÆ** Oustalet.

Cat. No. 211256, male adult. Guam, November 20, 1907.

Cat. No. 211257, male adult. Guam, November 21, 1907.

**MYZOMELA RUBRATRA** (Lesson).

Cat. No. 211258, male adult. Guam, November 20, 1907.

Cat. No. 211259, male adult. Guam, November 21, 1907.

**APLONIS KITTLITZI** (Finsch and Hartlaub).

Cat. No. 211260, male adult. Guam, November 19, 1907.

Cat. No. 211261, female adult. Guam, November 19, 1907.

Cat. No. 211262, female, immature. Guam, November 19, 1907.

**BIRDS COLLECTED AT MIDWAY ISLAND AND VICINITY.****STERNA FUSCATA CRISSALIS** (Lawrence).

Cat. No. 211229, immature. Midway Island, Hawaiian Islands, November, 1907.

**OCEANODROMA LEUCORHOA** (Vieillot).

Cat. No. 211225, male adult. Near Midway Island, Hawaiian Islands, latitude 27° 20' N., longitude 172° 45' W., November 5, 1907.

Cat. No. 211226, male adult. Near Midway Island, Hawaiian Islands, latitude 27° N., longitude 179° E., November 9, 1907.

Cat. No. 211227, adult. Near Midway Island, latitude 26° N., longitude 174° 16' E., November 11, 1907.

Cat. No. 211228, female adult. Near Midway Island, latitude 26° N., longitude 174° 16' E., November 11, 1907. "Obtained at 10 p. m."

**OCEANODROMA TRISTRAMI** Stejneger.

Cat. No. 211224, female adult. Near Midway Island, Hawaiian Islands, latitude 28° 15' N., longitude 176° 30' W., November 6, 1907. The skin of this specimen of the very rare Tristram's fork-tailed petrel measures as follows: Length, 245 mm.; wing, 175; tail, 118; exposed culmen, 17.5; tarsus, 27; middle toe with claw, 26.

**PUFFINUS CUNEATUS** Salvin.

Cat. No. 211222, female adult. Near Midway Island, Hawaiian Islands, latitude 28° 15' N., longitude 176° 30' W., November 6, 1907.

**PORZANULA PALMERI** Frohawk.

Cat. No. 211250, male adult. Eastern Island, Midway Island, Hawaiian group, November 7, 1907.

Cat. No. 211251, female adult. Eastern Island, Midway Island, Hawaiian group, November 7, 1907. Doctor Bartsch informs me that this species had been introduced from Laysan Island some years previously and was abundant at the time of his visit.

**CHARADRIUS DOMINICUS FULVUS** (Gmelin).

Cat. No. 211230-1, male adults. Sand Island, Midway Island, Hawaiian Islands, November 8, 1907.

Cat. No. 211232-3, male adults. Eastern Island, Midway Island, Hawaiian Islands, November 7, 1907.

**ARENARIA INTERPRES** (Linnæus).

Cat. No. 211234, male adult. Sand Island, Midway Island, Hawaiian group, November 8, 1907.

Cat. No. 211235-9, female adults. Sand Island, Midway Island, Hawaiian group, November 8, 1907.

**NUMENIUS TAHITIENSIS** (Gmelin).

Cat. No. 211242-6, female adults. Sand Island, Midway Island, Hawaiian group, November 8, 1907.

Cat. No. 211247-9, female adults. Eastern Island, Midway Island, Hawaiian group, November 7, 1907.

**PISOBIA AURITA** (Latham).

Cat. No. 211240-1, female adults. Sand Island, Midway Island, Hawaiian group, November 8, 1907.

**TELESPYZA CANTANS** Wilson.

Cat. No. 211252-3, male adults. Eastern Island, Midway Island, Hawaiian group, November 7, 1907. Introduced from Laysan Island.

# ADDITIONAL NOTES ON MAMMALS OF THE RHIO-LINGA ARCHIPELAGO, WITH DESCRIPTIONS OF NEW SPECIES AND A REVISED LIST.

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Since the publication of the very complete list of the mammals of the Rhio-Linga Archipelago, by Mr. Gerrit S. Miller, jr.,<sup>a</sup> and a short paper by me on the mammals of Batam Island, collected by Mr. C. Boden Kloss,<sup>b</sup> Dr. W. L. Abbott has presented to the U. S. National Museum mammals from five other islands of the Rhio-Linga Archipelago. These specimens are mentioned in detail below, among them being three species hitherto undescribed. The islands recently visited by Dr. W. L. Abbott are Bulan (or Bulang), Jombol (or Chombol), Galang, Setoko, and Penjait Layer. The first three are shown on the map of the Rhio-Linga Archipelago published with Mr. Miller's paper. Setoko appears on the map lying just northeast of Rempang, but is not named. Penjait Layer is a small island not shown on the map, but lies to the south of Setoko, from which it is separated by a strait about one-third mile wide.

At the conclusion of this paper is given a list of all the mammals known to occur on the islands of the Rhio-Linga Archipelago based upon the present material and the two papers mentioned.

## MANIS JAVANICA Desmarest.

1822. *Manis javanica* DESMAREST, Mammalogie, Pt. 2, p. 37.

Skin and skull of an adult male, from Pulo Bulan, Cat. No. 144418, U.S.N.M. Measurements: Head and body, 600 mm.; tail from anus, 505; hind foot, 99; weight, 9 kilos (20 pounds); greatest length of skull, 101; zygomatic width, 31.5. The zygomatic arch is complete and bony on each side. On the right side the posteriorly directed zygomatic process of the maxilla has met the anteriorly directed process of the squamosal. On the left side a similar condition exists, but the ossification has taken place in such a manner that a distinct

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<sup>a</sup> Proc. U. S. Nat. Mus., XXXI, No. 1485, pp 247-286, Sept. 11, 1906.

<sup>b</sup> Idem, XXXI, No. 1502, pp. 653-657, Jan. 16, 1907.

bony segment is intercalated between the process of the maxilla and that of the squamosal, presenting the appearance of a true jugal or malar bone.

"Caught a *Manis* in Bulan. It was up a small tree about 20 feet and I could not at first tell what it was. I cut the sapling down and seized the *Manis* by the tail as he was running away." W. L. A.

#### SUS RHIONIS Miller.

1906. *Sus rhionis* MILLER, Proc. U. S. Nat. Mus., XXX, No. 1466, p. 749, June 13, 1906. (Type-locality, Pulo Ungar.)

The skins and skulls of two pigs collected on Pulo Jombol are clearly referable to this species, agreeing in all essential respects with the original series from the islands of Ungar, Sugi Bawa, and Great Karimon.

For external and cranial measurements see table below.

#### SUS VITTATUS Müller and Schlegel.

1839-44. *Sus vittatus* MÜLLER and SCHLEGEL, Verh. Natuur. Gesch. Nederl. Bezitt. Zool., p. 172, pls. 29, 32. (Type-locality, Sumatra, restriction by Jentink, Notes Leyden Museum, XXVI, p. 175, Oct. 16, 1905.)

The skin and skull of an adult male from Pulo Penjait Layer is indistinguishable from the Sumatran *Sus vittatus* and is quite distinct from *Sus rhionis* Miller, found elsewhere on the Rhio-Linga Archipelago.

For external and cranial measurements see table below.

#### External and cranial measurements of *Sus rhionis* and *Sus vittatus*.

Dimensions.	Cat. No. 144380, adult male, Pulo Jombol, <i>Sus rhionis</i> .	Cat. No. 144379, nearly adult fe- male, Pulo Jombol, <i>Sus rhionis</i> .	Cat. No. 144421, adult male, Pulo Penjait Layer, <i>Sus vittatus</i> .
Head and body <i>a</i> , <i>mm</i> .....	1,150	1,025	1,160
Tail <i>a</i> .....	255	195	220
Hindfoot <i>a</i> .....	259	244	250
Height at shoulder <i>a</i> .....	560	490	500
Weight in pounds (in kilos) <i>a</i> .....	95(43)	58(26)	94(43)
Upper length of skull, <i>mm</i> .....	297	270	311
Basal length.....	265	241	272
Basilar length.....	250	225	256
Palatal length.....	187	166	192
Width of palate at <i>pm</i> <sup>1</sup> .....	30	27	31
Least width of palate at front of <i>m</i> <sup>2</sup> .....	21	21	27
Width of palate including <i>m</i> <sup>3</sup> .....	58	56	63
Zygomatic breadth.....	124	107	136
Least interorbital breadth.....	62	53	65
Parietal constriction.....	25	-----	36
Nasal breadth at posterior extremity of premaxilla.....	29	26	31
Length of nasals.....	142	128	142
Occipital depth to basion.....	82	71	91
Mandible.....	232	206	239
Maxillary toothrow, exclusive of canine.....	97	( <i>b</i> )	95
Second upper molar.....	18×15.5	20×17	19×16
Third upper molar.....	28×18.5	( <i>b</i> )	29×18.5
Mandibular toothrow, excluding anterior <i>pm</i> .....	90	( <i>b</i> )	92
Second lower molar.....	17×12.5	19×14	16.5×12
Third lower molar.....	27.15	( <i>b</i> )	30×15.5

<sup>a</sup> Collector's measurements.

<sup>b</sup> Last molars not entirely through alveoli.



TRAGULUS PERFLAVUS Miller.

1906. *Tragulus perflavus* MILLER, Proc. U. S. Nat. Mus., XXXI, No. 1485, p. 251, Sept. 11, 1906. (Batam Island.)

1907. *Tragulus perflavus* LYON, Proc. U. S. Nat. Mus., XXXI, No. 1502, p. 635, Jan. 16, 1907. (Batam and Galang islands.)

Twenty-seven specimens of this well-marked species of mouse-deer have now been sent to the National Museum. At the time it was described it was known by but a single specimen taken by Mr. C. Boden Kloss on Batam Island. Since then Mr. Kloss has collected 9 additional specimens on Batam, and 3 from Gong Hill, Pulo Galang. Doctor Abbott has recently collected 6 on Pulo Setoko and 8 on Pulo Bulan. The amount of individual variation in this large series is not great so far as color and markings are concerned, consisting chiefly in the intensity of the yellow color on the upper parts of the body behind the shoulders. In some individuals the black tips of the hairs on the back are quite conspicuous, thus obscuring the yellow color. The neck, however, in all the specimens is always strongly yellowish, without admixture of darker colors, and in none of the specimens does it make any approach to the neck coloration found in *Tragulus flavicollis* Miller from Pulo Sugi. The type-specimen of *T. perflavus* is about the average of the series so far as color is concerned.

In external and cranial measurements there is more individual variation in the series than there is in the color and markings. See table.

External and cranial measurements of *Tragulus perflavus*.

Locality.	Cat. No., U.S.N.M.	Sex.	Age.	Head and body.	Tail vertebra.	Hind foot, in- cluding hoof.	Weight.	Weight.	Basal length of skull.	Zygomatic breadth.	Maxillary tooth- row (alveol).	Mandibular toothrow (al- veol).
				mm.	mm.	mm.	lbs.	kilos.	mm.	mm.	mm.	mm.
Pulo Galang.....	143196	Male	Immature...	465	75	130	4	1.8	84.9	43.0	.....	.....
Do.....	143197	Female	Adult.....	535	80	137	7	3.2	96.0	49.5	35.0	41.5
Do.....	143199	do.	do.....	525	85	137	5½	2.5	92.3	45.5	34.6	43.0
Pulo Setoko.....	144422	do.	Young.....	430	81	121	4	1.8	80.0	41.5	.....	.....
Do.....	144426	do.	Nearly adult	490	80	135	5½	2.4	89.0	45.5	37.0	40.5
Do.....	144427	do.	Adult.....	495	75	132	6½	3.1	93.5	47.7	37.0	42.0
Do.....	144423	Male	do.....	482	80	129	5	2.3	90.0	44.5	37.0	43.7
Do.....	144424	do.	do.....	480	80	131	5½	2.5	89.0	47.0	34.5	41.6
Do.....	144425	do.	do.....	484	90	130	5	2.3	88.5	45.4	36.0	41.0
Pulo Bulan.....	144394	Female	Young.....	412	60	117	.....	.....	73.5	41.0	.....	.....
Do.....	144400	do.	do.....	467	75	134	4½	1.9	83.4	42.0	.....	.....
Do.....	144395	do.	Nearly adult	510	80	131	5½	2.6	89.8	45.9	37.4	41.7
Do.....	144401	do.	Adult.....	503	70	125	6	2.7	92.6	47.5	34.8	39.5
Do.....	144396	do.	do.....	530	84	136	7	3.2	.....	48.0	38.0	43.0
Do.....	144397	do.	do.....	532	85	137	6½	3.0	100.0	49.4	35.5	41.0
Do.....	144399	Male	do.....	475	67	130	5	2.3	91.5	49.5	39.0	42.6
Do.....	144398	do.	do.....	.....	.....	135	.....	.....	93.7	51.0	35.6	41.6
Pulo Batam.....	143200	Female	do.....	.....	.....	120	.....	.....	92.0	48.0	37.4	44.0
Do.....	143205	do.	do.....	635	78	137	7½	3.5	96.8	47.2	38.0	43.2
Do.....	144439	do.	do.....	.....	.....	127	.....	.....	89.7	48.2	36.3	41.4
Do.....	142125 <sup>a</sup>	do.	do.....	620	85	137	5½	2.5	97.6	48.8	37.0	41.3
Do.....	143202	Male	Nearly adult	583	82	131	4½	2.2	89.0	46.0	37.0	40.5
Do.....	143203	do.	Adult.....	585	77	130	5½	2.5	91.7	47.3	37.0	42.0
Do.....	144438	do.	do.....	.....	.....	128	.....	.....	91.8	47.9	36.5	42.0

<sup>a</sup> Type.

## SCIURUS PENINSULARIS Miller.

1903. *Sciurus peninsularis* MILLER, Smiths. Misc. Coll., XLV, p. 10, Nov. 6, 1903. (Type-locality Pahang.)

Six squirrels of the *vittatus* group from Pulo Bulan are referable to *Sciurus peninsularis* Miller. This is the same species that I have elsewhere called *Sciurus vittatus vittatus*.<sup>a</sup>

For measurements see table, page 483.

## RATUFA BULANA, new species.

*Type*.—Skin and skull of adult female, Cat. No. 144412, U.S.N.M., collected on Pulo Bulan, Rhio-Linga Archipelago, March 23, 1907, by Dr. W. L. Abbott. Original number, 5130.

*Diagnostic characters*.—Very similar to *Ratufa insignis* Miller,<sup>b</sup> from Pulo Sugi, but differing in having the naso-frontal suture shorter and the foramen leading from the orbital fossa into the posterior nares distinctly smaller.

*Color*.—Type: General effect of upper parts of body isabella color; posterior portion of upper part of head same, but finely grizzled by lighter annulations of similar color of the hairs; anterior portion of upper surface of head dark hair brown, slightly and finely grizzled with whitish; outer surfaces of thighs, forelegs, and a narrow line along sides of body russet; tail generally similar in color to the back; the hairs both above and below with lighter bases and the under side of the tail in the middle line with short appressed cream-colored hairs; under parts of body, throat, chin, inner side of fore and hind legs and sides of head beneath ears whitish; upper surface of hands and feet whitish, but irregularly suffused with a bright russet color, especially about the toes; sides of head and nose whitish, but darkened by brownish tips to the hairs; ears in general blackish brown, but with many lighter hairs on the inside.

*Series*: The series of *Ratufa bulana* is quite uniform in color and none of the specimens depart much from the color of the type. One specimen, an adult female, Cat. No. 144408, U.S.N.M., is rather lighter in color, being generally clay-color above.

*Skull and teeth*.—The skulls of *Ratufa bulana* differ from those of *R. insignis*, its nearest ally, in two very constant features, the relatively short naso-frontal suture and the small size of the foramen leading from the orbital fossa into the posterior nares. In *R. insignis* the nasals taken both together have an hourglass constriction just posterior to the middle, which is lacking in *R. bulana* owing to the

<sup>a</sup> Smiths. Misc. Coll., XLVIII, p. 278, Feb. 4, 1907; Proc. U. S. Nat. Mus., XXXI, p. 653, Jan. 16, 1907; Proc. U. S. Nat. Mus., XXXIV, p. 626, Sept. 14, 1908.

<sup>b</sup> Smiths. Misc. Coll., XLV, p. 4, Nov. 6, 1903.

shorter naso-frontal suture. I can detect no differences between the teeth of the two species.

Measurements.—See table below.

Specimens examined.—Five, all from Pulo Bulan.

Remarks.—*Ratufa bulana* is very closely related to *R. insignis*. The skins of the type-specimens appear sufficiently distinct, but the type of *R. insignis* is evidently in an unworn and unbleached pelage, while the pelage of the series of *R. bulana* is much bleached. One of the paratypes of *R. insignis*, Cat. No. 115532, U.S.N.M., is practically indistinguishable externally from Cat. No. 144410, one of the paratypes of *R. bulana*. All of the specimens of the latter species, however, have the forelegs and thighs more russet than does the series of *R. insignis*. The cranial characters serve to separate the two forms instantly.

External and cranial measurements of squirrels.

Name.	Locality.	Cat. No., U.S.N.M.	Sex.	Age.	Head and body. <sup>a</sup>	Tail vertebra. <sup>a</sup>	Hind foot with claws. <sup>b</sup>	Greatest length of skull.	Zygomatic width.	Interorbital constriction.
<i>Ratufa bulana</i> .....	Pulo Bulan.	144411	Male....	Adult....	mm. 347	mm. 403	mm. 80	mm. 65	mm. 41	mm. 27
Do.....	do.....	144408	Female....	do.....	330	385	72	64.5	39.3	26.7
Do.....	do.....	144409	do.....	do.....	328	405	79	64	39.5	27.6
Do.....	do.....	144410	do.....	do.....	342	413	82	66.5	40.2	27
Do.....	do.....	144412	do.....	do.....	327	400	84	65.3	39	26.8
<i>Sciurus peninsularis</i> .....	do.....	144402	do.....	do.....	218	197	51	50.9	31.3	18.4
Do.....	do.....	144403	do.....	do.....	210	190	54	50.3	31.2	17.9
Do.....	do.....	144404	do.....	do.....	222	200	53	52.3	31.3	18.3
Do.....	do.....	144405	do.....	do.....	220	(d)	50			
Do.....	do.....	144406	Male.....	do.....	226	196	51	51.4	31.8	19.6
Do.....	do.....	144407	do.....	do.....	220	190	52	50	31.3	18.7

<sup>a</sup> Collector's measurements. <sup>c</sup> Type.  
<sup>b</sup> Measured by writer after relaxing feet in water. <sup>d</sup> Defective.

MUS ASPER Miller.

1900. *Mus asper* MILLER, Proc. Biol. Soc. Washington, XIII, p. 145, Apr. 21, 1900.

One specimen, skin and skull of an adult female, from Pulo Setoko. This is the second specimen of the *Mus asper* group of rats known from the Rhio-Linga Archipelago. The other is the type of *Mus batamanus* from Pulo Batam, which I wrongly referred in the original description <sup>a</sup> to the *Mus jerdoni* group. A reexamination shows it to be a member of the *Mus asper* group. The infrequency with which rats of this group have been taken in the Rhio-Linga Archipelago is surprising, in view of their common occurrence on the Malay Peninsula, Sumatra, Banka, and Billiton.

For measurements of the Setoko specimen, see table, page 485.

<sup>a</sup> Proc. U. S. Nat. Mus., XXXI, No. 1502, p. 654, January 16, 1907.



## MUS LINGENSIS Miller.

1900. *Mus lingensis* MILLER, Proc. Washington Acad. Sci., II, p. 206, Aug. 20, 1900.

Of this rat, which is so widely distributed in the Rhio-Linga Archipelago, Doctor Abbott secured 10 individuals (8 skins and skulls, and 2 in alcohol) on Pulo Jombol.

For external and cranial measurements, see table, page 485.

## MUS FIRMUS Miller.

1902. *Mus firmus* MILLER, Proc. Acad. Nat. Sci., Philadelphia, 1902, p. 155, June 11, 1902.

Two specimens from Pulo Setoko do not differ from *Mus firmus* as found elsewhere in the Rhio-Linga Archipelago.

For measurements, see table, page 485.

## MUS CHOMBOLIS, new species.

*Type*.—Skin and skull of adult female, Cat. No. 144393, U.S.N.M., collected on Pulo Jombol, Rhio-Linga Archipelago, March 10, 1907, by Dr. W. L. Abbott. Original number, 5100.

*Diagnostic characters*.—Similar to *Mus firmus* Miller,<sup>a</sup> but slightly darker in color, smaller in size, and with distinctly smaller skull.

*Color*.—Upper parts and sides of head and body, a coarse grizzle of brownish black and pale ochraceous buff, the brownish black in excess along the dorsal line. Along the sides the slate gray of the underfur shows through on the surface. Underparts and inner surfaces of legs dirty cream color; feet dull brownish, tail and ears dull dark brownish.

*Pelage, etc*.—The pelage consists of three types of hair—the relatively short, dark, gray underfur; soft, weak hairs, with dark-gray bases, light ochraceous buff subterminal rings, and short blackish-brown apices; relatively long, soft, grooved, brownish-black bristles. Tail concolor, dark brownish, 10 scales to the centimeter in the middle portion; each scale subtended by 3 hairs, each of which is equal to about 1 scale in length.

*Skull and teeth*.—The skull of *Mus chombolis* in general resembles that of *M. firmus*, but is distinctly smaller and lighter throughout, especially noticeable in the rostral portion, which is much shorter and narrower and much less deep; the bullæ are smaller; the incisive foramina shorter; the anterior nares smaller. The maxillary tooth row is distinctly shorter in *M. chombolis* than it is in *M. firmus* and the individual teeth smaller; the incisors are also smaller and weaker.

<sup>a</sup> Proc. Acad. Nat. Sci. Phila., 1902, p. 155, June 11, 1902; Proc. U. S. Nat. Mus., XXXI, No. 1485, p. 266, Sept. 11, 1906.



*Measurements.*—External: Head and body, 195 mm. (245)<sup>a</sup>; tail, 230 (255); hind foot with claws, 45 (47.5). Cranial: Greatest length of skull, 46.8 (52.7); length of nasals in middle line, 17.9 (20.5); basal length, 41 (47); zygomatic width, 23.5 (26.2); width of rostrum at antorbital foramen, 8.5 (10.3); width of brain case above roots of zygomata, 19 (21.2); least depth of rostrum, 8.7 (10.3); maxillary tooth row (alveoli), 8.2 (10).

*Specimens examined.*—One, the type.

*Remarks.*—Although the rats of the *Mus firmus* group hitherto known from the various islands of the Rhio-Linga Archipelago are referable to typical *firmus* (type-locality, Linga Island), the single known rat of this group from Pulo Jombol appears too different to be regarded as belonging to the same species as the others. That its small size is not due to immaturity is shown by a considerable amount of wear of the teeth, the closure of skull sutures, which remain open in young animals, and the perfect development of angles and ridges on the skull. An examination of many skulls of *Mus firmus* from the islands of the Rhio-Linga Archipelago fails to show any that approach the skull of *M. chombolis* in its general small size, short rostrum, and smaller teeth. The somewhat darker color of *M. chombolis* can not be considered as characteristic, and externally, aside from its smaller size, it can scarcely be differentiated from *M. firmus*.

*External and cranial measurements of rats.*

Name.	Locality.	Cat. No. U.S.N.M.	Sex.	Age.	Head and body. <sup>a</sup>	Tail vertebrae. <sup>a</sup>	Hind foot with claws.	Greatest length of skull.	Zygomatic width.	Maxillary tooth row.
<i>Mus lingensis</i> .....	Pulo Jombol	144384	Female	Adult...	mm. 204	mm. 148	mm. 39	mm. 44.5	mm. 22	mm. 6.6
Do.....	do.	144385	do.	do.	214	160	41	46.8	22	6.7
Do.....	do.	144386	do.	do.	216	171	42	47	21.6	6.9
Do.....	do.	144390	do.	do.	210	.....	41	46.5	20.3	7
Do.....	do.	144383	Male	do.	220	178	44	48.2	.....	6.6
Do.....	do.	144387	do.	do.	220	171	45	48.6	21.7	7.2
Do.....	do.	144388	do.	do.	214	164	44	47.7	22.8	6.8
Do.....	do.	144389	do.	do.	207	151	44	47	20.2	6.8
<i>Mus chombolis</i> .....	do.	144393	Female	do.	195	255	45	46.8	23.5	8.2
<i>Mus firmus</i> .....	Pulo Setoko.	144428	do.	do.	226	242	50	52	25.7	9.7
Do.....	do.	144429	Male	do.	247	241	51	56.5	26	9.3
<i>Mus asper</i> .....	do.	144430	Female	do.	135	99	31	.....	15.8	5.8

<sup>a</sup> Collector's measurements.

AONYX CINEREA (Illiger).

1815. *Lutra cinerea* ILLIGER, "Abh. Akad. Berlin, 1811, p. 99, 1815." (Type-locality near Batavia, Java.)

Skin and skull of an adult female, Cat. No. 144434, U.S.N.M., from Pulo Setoko. The size of the teeth in the specimens of clawless

<sup>a</sup> Measurements in parentheses are those of the type of *Mus firmus*.

otters in the U. S. National Museum is quite variable. The above specimen and one from Great Karimon Island, Cat. No. 122840, U.S.N.M., have remarkably large and heavy teeth as compared with a skull from Tapanuli Bay, Sumatra, and a skull from northern Borneo. A very young skull from Pulo Sebang, Rhio Linga Archipelago, has small teeth about like those of the Sumatran skull. The significance of this variation in the size of teeth is not clear. It is not sexual. A similar variation in the shape of the ascending ramus of the mandible is seen, no two of them being exactly alike. See Plate 39.

*Measurements.*—Head and body, 495 mm.; tail, 290; hind foot, 95; weight, 6 pounds (2.7 kilos); basal length of skull, 82; zygomatic width, 57.5; maxillary tooth row (alveoli), 29.

"The morning I left Setoko the natives brought me a fine female clawless otter which they had hit over the head with a paddle while swimming across the s'lat [strait]. One day a large otter swam across the s'lat close ahead of the schooner, but my men were too slow for him. \* \* \* They doubtless feed upon shell fish, among other things, and I know they eat crabs."

W. L. ABBOTT.

ARCTOGALIDIA FUSCA Miller.

1906. *Arctogalidia fusca* MILLER, Proc. U. S. Nat. Mus., XXXI, No. 1485, p. 269, Sept. 11, 1906. (Type-locality, Pulo Kundur.)

An immature male from Pulo Bulan, Cat. No. 144420, U.S.N.M., is indistinguishable from *Arctogalidia fusca* Miller.

External measurements by collector: Head and body, 475 mm.; tail, 545; hind foot, 90; weight, 1.6 kilos (3½ pounds). Cranial measurements: Greatest length, 99.4; basal length, 93.5; zygomatic breadth, 53; postorbital constriction, 19; width of brain-case above roots of zygomata, 33; maxillary tooth row (alveoli), 34.6.

GALEOPTERUS CHOMBOLIS, new species.

*Type.*—Skin and skull of adult female, Cat. No. 144375, U.S.N.M., collected on Pulo Jombol, Rhio-Linga Archipelago, March 3, 1907, by Dr. W. L. Abbott. Original number, 5091.

*Diagnostic characters.*—A medium-sized member of the genus, closely related to *Galeopterus tuancus* (Miller),<sup>a</sup> but having wider zygomata, more inflated mastoids, and smaller first upper incisors.

*Color.*—The color of the type and two adult female paratypes differs in no essential respects from that of flying-lemurs in the gray pelage phase from the Malay Peninsula, being, perhaps, a trifle paler in general color effect. Another paratype, an adult male, is in the "red" phase, having the general color effect of cinnamon-rufous,

<sup>a</sup> Smiths. Misc. Coll., XLV, p. 53, Nov. 6, 1903.

very light and clear on the under parts, darker and mixed with blackish above. The usual white flecks are found on the feet and legs and a few on the back.

*Skull and teeth.*—The skull and teeth of *Galeopterus chombolis* are very similar to those of *G. tuancus* in general appearance. There are, however, several minor constant differences found in the animal from Jombol. The zygomata are wider, the lateral area of the mastoid much greater, the first upper incisor distinctly smaller, the third upper incisor somewhat larger, and the notch at the superior end of anterior border of premaxilla much larger and more angular.

*Measurements.*—See table below.

*Specimens examined.*—One adult male and 3 adult females, all from Pulo Jombol.

*Remarks.*—Aside from *G. tuancus*, the only other species with which *G. chombolis* needs to be compared is *G. tellonis* (Lyon).<sup>a</sup> Unfortunately, I have not been able to make a direct comparison between the two species, but the description of *G. tellonis* shows that the mastoid inflation is even less than in *G. tuancus*, and consequently much less in *G. chombolis*.

#### Measurements of Galeopterus.

Name.	Locality.	Cat. No., U.S.N.M.	Sex.	Age.	Head and body. <sup>a</sup>	Tail. <sup>a</sup>	Hind foot with claws. <sup>b</sup>	Greatest length of skull.	Zygomatic width.	Interorbital constriction.	Upper tooth-row (all teeth), alveoli.
<i>G. tuancus</i> .....	Pulo Tu- anku.	114375	Female..	Adult...	mm. 385	mm. 235	mm. 62	mm. 68.4	mm. 44.3	mm. 19	mm. 32.4
<i>G. chombolis</i> .....	Pulo Jom- bol.	144372	Male.....	...do.....	370	220	60.5	65.9	42	16.6	30.4
Do.....	do.....	144373	Female..	...do.....	390	260	62	69.7	42.9	18.7	31.8
Do.....	do.....	144375	...do.....	...do.....	400	250	61	69.3	43.4	17.8	32.3
Do.....	do.....	144377	...do.....	...do.....	370	250	61	68.1	41	18	31

<sup>a</sup> Collector's measurements.

<sup>b</sup> Measured by writer from dried skin.

<sup>c</sup> Type.

#### CYNOPTERUS MONTANOI Robin.

1881. *Cynopterus montanoi* ROBIN, Bull. Soc. Phil. Paris, 7th ser., V, p. 90.  
(Type-locality, Malacca.)

One specimen each from Pulo Bulan and Pulo Jombol, and two from Setoko. This species appears to be widely distributed throughout the archipelago.

For measurements, see table, page 488.

<sup>a</sup>Ann. Mag. Nat. Hist., 8th ser., I, p. 139, February, 1908.

## EMBALLONURA PENINSULARIS Miller.

1898. *Emballonura peninsularis* MILLER, Proc. Acad. Nat. Sci. Philadelphia, 1898, p. 323, July 25, 1898. (Type-locality, Trong, Lower Siam.)

Four specimens from Pulo Bulan. For measurements see table, below.

This species is probably identical with *Emballonura monticola* Temminck.<sup>a</sup> Temminck's standard of measurement was probably the *piec du roi*. His 1 inch and 7 lines as length of forearm then equals nearly 43 mm. Mr. Miller in describing *E. peninsularis* converted 1 inch and 7 lines on the basis of the English inch, which gave the length of forearm as 40 mm. and made all the other measurements correspondingly smaller. In the absence of specimens from Java for actual comparison, I have used the name *peninsularis*.

## MYOTIS MURICOLA (Gray).

1841. *Vespertilio muricola* HODGSON, Journ. Asiat. Soc. Bengal, X, p. 908 (*Nomen nudum*)

1846. *Vespertilio muricola* GRAY, Cat. Spec. Draw. Mamm. Birds Nepal and Thibet, presented by Hodgson to Brit. Mus., p. 4.

One specimen, an adult female, preserved in alcohol, from Pulo Setoko.

For measurements see table below.

## Measurements of bats.

Name.	Locality.	Cat. No., U.S.N.M.	Sex and age.	Head and body.		Forearm.	Tibia.	Foot.	Ear from crown.	Greatest length of skull.	Maxillary tooth row, including canine.
				mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
<i>Cynopterus montanoi</i>	Pulo Bulan.	144417	Male adult.	82	7	61	23	13	15	28.6	9.5
Do.	Pulo Jombol.	144381	Female adult	75	7	59	23	13	15.5	26.6	8.9
Do.	Pulo Setoko.	144431	Male adult.	84	11	64	24	13	15	30	9.5
Do.	do.	144432	do.	83	10	62	24	14	14.5	28.5	9.2
<i>Emballonura peninsularis</i> .	Pulo Bulan.	144413	do.	40	11	43	16	7	9	.....	.....
Do.	do.	144414	do.	40	11	41	15	7	10	.....	.....
Do.	do.	144415	Female adult	43	10	42	15	7.5	10.5	13.7	5
Do.	do.	144416	do.	45	12	44	17	8	12	13.9	4.6
<i>Myotis muricola</i>	Pulo Setoko.	144433	do.	40	34	34.5	16	7	11	8.7	5.3

## MACACA FASCICULARIS (Raffles).

1822. *Simia fascicularis* RAFFLES, Trans. Linn. Soc. London, XIII, p. 246, 1822. (Type-locality, Sumatra.)

Skin and skull of an adult male, Cat. No. 144419, U.S.N.M., collected on Pulo Bulan. This specimen is grayer and less reddish than the majority of examples of this species.

<sup>a</sup> Tydschr. Natuur. Gesch. Physiol. Leiden, V, p. 25, 1838, type-locality, Java.



Measurements by collector: Head and body, 472 mm.; tail, 530; hind foot, 126; weight, 10 $\frac{3}{4}$  pounds, 4.9 kilos. Cranial measurements: Basal length, 83; zygomatic width, 75.3; maxillary tooth row (alveoli), 35.6.

PRESBYTIS CRISTATA (Raffles). .

1822. *Simia cristata* RAFFLES, Trans. Linn. Soc. London, XIII, p. 244, 1822.  
(Type-locality, Sumatra.)

Skin and skull of an adult male, Cat. No. 144371, U.S.N.M., collected on Pulo Jombol.

Measurements by collector: Head and body, 510 mm.; tail, 660; hind foot, 151; weight, 15 pounds, 6.8 kilos. Cranial measurements: Basal length, 66.8; zygomatic width, 71.4; maxillary tooth row (alveoli), 32.

LIST OF MAMMALS OF THE RHIO-LINGA ARCHIPELAGO.

The name of each species is followed by the names of the islands on which it occurs. When the species is not represented by actual specimens in the U. S. National Museum collection, but is noted as occurring on certain islands by Dr. W. L. Abbott or Mr. C. Boden Kloss, the name of the island is printed in italics.

*Manis javanica*. Bulan, *Kundur*, *Penuba*, *Sanglar*, *Sinkep*.

*Tragulus flavicollis*. Sugi.

*Tragulus formosus*. Bintang.

*Tragulus* sp., *kanchil* group. *Batam*, *Little Karimon*?, *Penuba*.

*Tragulus lutescens*. Sugi Bawa, Jani.

*Tragulus* sp., *napa* group *Durian*?, *Little Karimon*?, *Moro Kechil*, *Penuba*.

*Tragulus nigricollis*. *Sinkep*.

*Tragulus nigrocinctus*. *Kundur*, Great *Karimon*.

*Tragulus perflavus*. *Batam*, Bulan, Galang, Setoko.

*Tragulus pretiellus*. Bakong, Sebang.

*Tragulus pretiosus*. Linga.

*Tragulus rubeus*. Bintang.

*Tragulus subrufus*. Linga, *Sinkep*.

*Sus oi*. *Batam*, *Kundur*, *Ungar*.

*Sus rhionis*. *Bakong*, *Batam*, *Durian*, Great *Karimon*, *Jombol*, *Little Karimon*, *Moro Kechil*, *Sanglar*, *Sugi*, *Sugi Bawa*, *Ungar*.

*Sus vittatus*. Penjait Layer. (Some of the islands listed under *Sus rhionis*, from which there are no specimens, may possibly have on them the present species instead of *S. rhionis*.)

*Ratufa bulana*. Bulan.

*Ratufa carimonensis*. Great *Karimon*.

- Ratufa condurensis*. Kundur.  
*Ratufa confinis*. Sinkep.  
*Ratufa conspicua*. Bintang.  
*Ratufa insignis*. Sugi.  
*Ratufa notabilis*. Linga.  
*Sciurus carimonensis*. Great Karimon.  
*Sciurus condurensis*. Kundur.  
*Sciurus peninsularis*. Batam, Bintang, Bulan, Little Karimon, Linga, Penuba, Sanglar, Sebang, Sinkep, Sugi.  
*Sciurus tenuis*. Batam, Linga.  
*Rhinosciurus laticaudatus*. Linga.  
*Sciuropterus amœnus*. Kundur.  
*Nannosciurus pulcher*. Sinkep.  
*Mus asper*. Setoko.  
*Mus batamanus*. Batam.  
*Mus chombolis*. Jombol.  
*Mus concolor*. Batam.  
*Mus firmus*. Bakong, Batam, Great Karimon, Linga, Moro Besar, Sebang, Setoko, Sugi, Sugi Bawa.  
*Mus fremens*. Linga, Sinkep.  
*Mus lingensis*. Bakong, Batam, Bintang, Great Karimon, Jombol, Linga, Moro Besar, Moro Kechil, Penuba, Sebang, Sinkep, Sugi, Sugi Bawa.  
*Mus "rattus."* Bakong, Batam, Great Karimon, Kundur, Moro Kechil, Sugi, Sugi Bawa.  
*Felis "tigris."* Bintang, Penjait Layer, Setoko.  
*Paradoxurus brunneipes*. Kundur.  
*Paradoxurus "hermaphroditus."* Batam.  
*Arctogalidia fusca*. Bintang, Bulan, Kundur.  
*Arctogalidia simplex*. Batam, Linga, Sinkep.  
*Viverra tangalunga*. Bintang, Linga, Kundur.  
*Arctictis binturong*. Bintang, Kundur.  
*Aonyx cinerea*. Great Karimon, Sebang, Setoko.  
*Tupaia castanea*. Bintang.  
*Tupaia ferruginea batamana*. Batam.  
*Tupaia malaccana*. Linga, Sinkep.  
*Tupaia phœura*. Sinkep.  
*Tupaia tana*. Linga.  
*Galeopterus chombolis*. Jombol.  
*Galeopterus temminckii*. Bakong, Batam, Bintang, Great Karimon, Kundur, Penuba, Sebang, Sugi.  
*Pteropus vampyrus malaccensis*. Linga.  
*Cynopterus montanoi*. Bulan, Jombol, Kundur, Penuba, Sanglar, Setoko, Sugi.

*Emballonura peninsularis*. Bintang, Bulan, Karimon Anak, Sanglar.

*Myotis muricola*. Setoko.

*Macaca fascicularis*. Bakong, Batam, Bintang, Bulan, Durian, Great Karimon, Kundur, Linga, Moro Kechil, Sebang, Sugi.

*Macaca nemestrina*. Batam.

*Presbytis cana*. Batam, Kundur.

*Presbytis cristata*. Bakong, Batam, Bintang, Jombol, Linga, Sebang, Sugi.

*Presbytis rhionis*. Bintang.

#### EXPLANATION OF PLATE 39.

View of under side of skulls and left half of mandibles of *Aonyx cinerea*, about  $\frac{2}{3}$  natural size.

Fig. 1. Cat. No. 144434, U.S.N.M., adult female, Pulo Setoko, Rhio-Linga Archipelago.

2. Cat. No. 114466, U.S.N.M., adult female, Tapanuli Bay, west coast of Sumatra.

3. Cat. No. 34904, U.S.N.M., Kinabatagan River, British North Borneo.

4. Cat. No. 122840, U.S.N.M., Great Karimon, Rhio-Linga Archipelago.

[NOTE.—Since the page proofs of this paper have been made up, Messrs. Oldfield Thomas and R. C. Wroughton have published in the Annals and Magazine of Natural History, eighth series, Volume III, pages 439–441, May, 1909, descriptions of the following six new mammals from the Rhio Archipelago:

*Presbytis cristata pullata*, p. 439, Batam, Bintang.

*Sciurus vittatus nesiotes*, p. 439, Batam.

*Sciurus scimundi*, p. 440, Kundur.

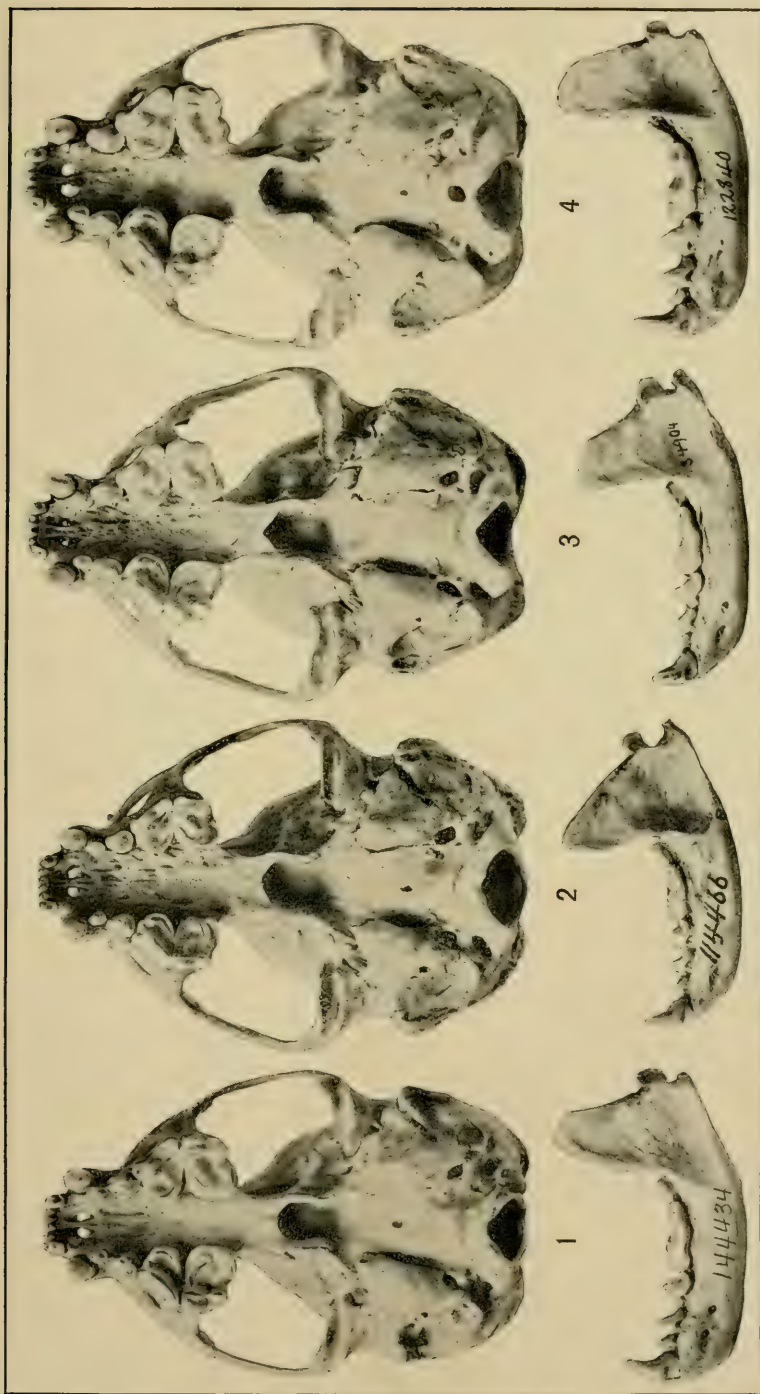
*Rhinosciurus leo rhionis*, p. 440, Karimon, Kundur, Batam, Bintang.

*Mus rattus rhionis*, p. 441, Bintang, Batam.

*Sus andersoni*, p. 441, Batam.—M. W. L., Jr.]







SKULLS OF CLAWLESS OTTERS.  
FOR EXPLANATION OF PLATE SEE PAGE 491.



# REVISION OF THE CRINOID FAMILY COMASTERIDÆ, WITH DESCRIPTIONS OF NEW GENERA AND SPECIES.

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By AUSTIN HOBART CLARK,

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The work of the steamer *Albatross*, of the United States Bureau of Fisheries, especially within the last two years, has resulted in the accumulation of a magnificent collection of comasterid material, practically every known and numerous heretofore unknown species being represented. This has been studied in connection with the remarkably comprehensive collection belonging to the zoological museum of the University of Copenhagen (previously studied by Drs. C. F. Lütken and P. H. Carpenter), for the privilege of examining which I am indebted to the generosity of my friend, Dr. Th. Mortensen; with the very fine collection of Japanese comasterids deposited in the U. S. National Museum by Mr. Frank Springer; with the collection made by the German steamer *Gazelle* in Australia, sent to me for study through the kindness of Drs. W. Weltner and R. Hartmeyer, and with the collections of a number of American museums. Still other collections have been examined at different times, and the notes made on them have proved of considerable value, the most important of these being the collection at the Museum of Comparative Zoology, which contains specimens identified by Carpenter, and that of the Boston Society of Natural History.

After the completion of the work on this "revision," the authorities of the Indian Museum at Calcutta, through the superintendent, Dr. N. Annandale, sent me the specimens collected by the steamer *Investigator*, which proved to be a collection of more than usual interest. It was with considerable gratification that I found, after a critical study of the *Investigator* material, no changes of any kind were necessary, and I was thereby induced to publish the "revision" in its present form, believing that, if such a large collection as that of the *Investigator* did not alter in any way the general scheme, there was a reasonable hope of at least as long a life as is enjoyed by most "revisions."

The history of the family Comasteridæ may be said to date from that most excellent memoir of Dr. P. H. Carpenter on the genus *Actinometra*. In this memoir he gives a detailed account of the systematic treatment of the various species of the genus by previous authors, and ably reduces to order a systematic chaos scarcely surpassed in the whole subject of zoology; for even so great a zoologist as Prof. Johannes Müller, in the only monograph then published on the unstalked erinoids, had placed a single species (under four different specific names) under the subgenus *Actinometra* among the exocyclic forms (twice); under the subgenus *Alecto* among the endocyclic forms, and again under the subgenerically *incertæ sedis*, in the heterogeneous group *Comatula*.

Since 1879 the genus *Actinometra* has been accepted in the sense in which it was used by Carpenter. Nine years afterwards he split it up into eight specific groups, distributing these among four "series," and this arrangement has been used ever since. Shortly afterwards the genus was raised to family rank, on a par with the family "Antedonidæ," covering the genus "*Antedon*" of Doctor Carpenter. This I have recently shown to be an unnatural division. In the course of my work I found the genus *Actinometra* becoming somewhat unwieldy, and I accordingly split it in two sections, one small and one large; but with the accession of new material the large division proved not to be natural, and I split that into two parts. Enormous collections from the Philippine Islands having been received, a still further change was seen to be necessary, and the last of the divisions created was shattered into three fragments. I discarded the appropriate and euphonious name *Actinometra* proposed by Professor Müller in favor of *Comatula* of Lamarek, of which it is a pure synonym, with the same type. While the name Comatulidæ was first employed to cover the family in place of Actinometridæ (not available because of the disuse of *Actinometra*), I soon found that confusion with the Comatuladæ of Fleming (1828) and Comatulidæ of d'Orbigny (1852) and succeeding authors, with a more or less comprehensive range of meaning, but never so restricted as to cover the "Actinometridæ" alone, made a change desirable, and I therefore substituted "Comasteridæ," the name being derived from that of the next oldest genus.

The most important discovery made in regard to the Comasteridæ since the publication of Carpenter's memoir in 1879 is that of Mr. Frank Springer, who in 1903 described and figured a strongly developed ambulacral plating on the arms and pinnules of a new species from the Tortugas. I have since found these plates to be universally present in the species of the "Fimbriata group" from the West Indies, well developed even in "*Actinometra*" *lineata*, in which I detected it in some of the *Challenger* specimens previously examined by



Carpenter. These plates appear to represent the side plates of the Pentacrinitidæ, Tropiometridæ, Thalassometridæ, Antedonidæ, etc., although performing the function of both side and covering plates. The latter are phylogenetically more advanced structures; whereas side plates are phylogenetically the thin produced ventrolateral border of the pinnulars and brachials which has become separated from the parent ossicle by suture, so covering plates are the produced inner distal angles of the side plates which have become secondarily separated off.

## KEY TO THE GENERA OF THE COMASTERIDÆ.

- a*<sup>1</sup>. Six pinnules following the first pair absent; mouth always central. (1) COMATILIA.
- a*<sup>2</sup>. All pinnules present; mouth usually more or less eccentric.
  - b*<sup>1</sup>. IBr<sub>1</sub> and<sub>2</sub> and first two joints after each axillary united by syzygy. (2) COMATULA.
  - b*<sup>2</sup>. IBr<sub>1</sub> and<sub>2</sub> and first two joints after the first axillary united by synarthry.
  - c*<sup>1</sup>. Cirri present.
    - d*<sup>1</sup>. Cirri without dorsal spines (ten arms).
      - e*<sup>1</sup>. First two pinnules much stouter than the succeeding; cirri long, slender, and numerous (XL)----- (3) COMINIA.
      - e*<sup>2</sup>. First two pinnules more slender than the succeeding; cirri short and stout, few in number (to XXVII)----- (4) COMACTINIA.
    - d*<sup>2</sup>. Cirri with dorsal spines or projections (ten or more arms).
      - e*<sup>1</sup>. Distal pinnules exceedingly slender with greatly elongated joints which have expanded articulations; ten arms. (5) LEPTONEMASTER.
      - e*<sup>2</sup>. Distal pinnules comparatively stout, the joints rarely over twice as long as broad, the articulations not expanded.
        - f*<sup>1</sup>. Ten arms; synarthrial tubercles prominent; pinnule joints with the distal ventro-lateral angle produced----- (6) COMISSIA.
        - f*<sup>2</sup>. More than ten arms; synarthrial tubercles not developed; no production of the distal ventro-lateral angles of the pinnule joints.
    - g*<sup>1</sup>. First brachial bearing a pinnule on arms arising from a IIBr or subsequent axillary; a syzygy between the second and third brachials.
      - h*<sup>1</sup>. Brachials in distal half of arm exceedingly short, almost discoidal; ambulacra naked----- (7) CAPILLASTER.
      - h*<sup>2</sup>. Brachials in distal half of arm triangular or very obliquely wedge-shaped, nearly or quite as long as broad; pinnule ambulacra with large side plates----- (8) NEMASTER.
    - g*<sup>2</sup>. First brachial never bearing a pinnule.
      - h*<sup>1</sup>. All division series 2; a syzygy between the first two brachials----- (9) COMATELLA.
      - h*<sup>2</sup>. Several or all of the division series 4 (3+4).
        - i*<sup>1</sup>. Proximal pinnules more slender than the succeeding; combs occur at intervals on the distal pinnules. (10) COMASTER.
        - i*<sup>2</sup>. Proximal pinnules stouter than the succeeding; no combs on the distal pinnules----- (11) COMANTHUS.
  - c*<sup>2</sup>. Cirri absent; centro-dorsal a thin pentagonal or stellate plate.
    - d*<sup>1</sup>. First brachial bearing a pinnule; first syzygy between the first two brachials----- (7) CAPILLASTER.

$d^2$ . First brachial never bearing a pinnule.

$e^1$ . Proximal pinnules more slender than the succeeding; terminal comb short, with long curved teeth, appearing at intervals along the distal pinnules.----- (10) COMASTER.

$e^2$ . Proximal pinnules stouter than the succeeding; terminal comb long with short rounded teeth, confined to the proximal pinnules.

(11) COMANTHUS.

SUPPLEMENTARY KEY TO GENERA CONTAINING SPECIES WITH TEN ARMS ONLY.

$a^1$ . Six pinnules following the first pair absent; large side plates developed along the pinnule ambulacra; opposing spine forked or branched.

(1) COMATILIA.

$a^2$ . All pinnules present; no ambulacral plating; opposing spine single.

$b^1$ .  $1Br_1$  and  $2$  and first two brachials united by syzygy----- (2) COMATULA.

$b^2$ .  $1Br_1$  and  $2$  and first two brachials united by synarthry.

$c^1$ . Cirri without dorsal spines or projections.

$d^1$ . First two pinnules much stouter than the succeeding; cirri long, slender, and numerous (XL)----- (3) COMINIA.

$d^2$ . First two pinnules more slender than the succeeding; cirri short and stout, few in number (to XXVII)----- (4) COMACTINIA.

$c^2$ . Cirri with dorsal spines or projections.

$d^1$ . Distal cirrus joints (except the penultimate) considerably longer than broad; synarthrial tubercles not developed; distal pinnules exceedingly slender, with greatly elongated joints which have expanded articulations----- (5) LEPTONEMASTER.

$d^2$ . Distal cirrus joints considerably broader than long; synarthrial tubercles prominent; distal pinnules comparatively stout, the joints rarely over twice as long as broad, the articulations not expanded----- (6) COMISSIA.

SUPPLEMENTARY KEY TO GENERA CONTAINING MULTIBRACHIATE SPECIES.

$a^1$ .  $1Br_1$  and  $2$  and first two joints beyond each axillary united by syzygy.

(2) COMATULA.

$a^2$ .  $1Br_1$  and  $2$  and first two joints beyond the first axillary united by synarthry.

$b^1$ . First brachial bearing a pinnule; first brachial syzygy between the second and third brachials.

$c^1$ . Brachials in distal half of arm exceedingly short, almost discoidal; ambulacra naked----- (7) CAPILLASTER.

$c^2$ . Brachials in distal half of arm triangular or very obliquely wedge-shaped, nearly or quite as long as broad; pinnule ambulacra with large side plates----- (8) NEMASTER.

$b^2$ . First brachial never bearing a pinnule.

$c^1$ . Division series all 2; first brachial syzygy between the first two brachials on all but the outermost arms----- (9) COMATELLA.

$c^2$ . Several or all of the division series 4 (3+4).

$d^1$ . Proximal pinnules more slender than the succeeding; combs occur at intervals along the distal pinnules----- (10) COMASTER.

$d^2$ . Proximal pinnules stouter than the succeeding; no combs on the distal pinnules----- (11) COMANTHUS.

## 1. Genus COMATILIA A. H. Clark.

1909. *Comatilia* A. H. CLARK, Proc. U. S. Nat. Mus., XXXVI, p. 365.

*Genotype*.—*Comatilia iridometrififormis* A. H. Clark (new species).

*Distribution*.—Only known from between the Bahama Islands and Cape Fear, North Carolina.

*Depth*.—Two hundred and eighty fathoms.

## 2. Genus COMATULA Lamarck (emended).

1758. *Asterias* (part) LINNÆUS, Syst. Nat., 10th ed., II, p. 663.

1772. *Asteria* (part) BRÜNNICH, Zoölogia fundamenta, p. 230 (emendation).

[1812. *Comatule* (part) LAMARCK, Extrait du cours de zoölogie du mus. d'hist. nat. sur les animaux sans vertèbres, p. 35 (no definition)].

1816. *Comatula* LAMARCK, Hist. nat. des animaux sans vertèbres, II, p. 530, emended 1908—A. H. CLARK, Proc. U. S. Nat. Mus., XXXIII, p. 685.

1841. *Actinometra* J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 140.

*Genotype*.—*Comatula solaris* Lamarck (new species).

*Distribution*.—Northern Australia to the Mergui Archipelago, China, and the Philippine Islands, ? Madagascar, ? Society Islands.

*Depth*.—Littoral and sublittoral.

## 3. COMINIA, new genus.

1908. *Comanthus* (part) A. H. CLARK, Proc. Biol. Soc. Washington, XXI, p. 220.

*Genotype*.—*Comanthus decameros* A. H. Clark, 1908.

*Description*.—Centro-dorsal discoidal, bearing numerous marginal cirri in roughly three irregular and crowded more or less alternating rows.

Cirri XL, 16–17; first joint very short, second slightly longer than broad to about twice as long as broad, third–sixth two and one-half to three times as long as broad, the following decreasing in length, the last two being squarish; opposing spine represented by a low tubercle; no dorsal spines or projections; terminal claw about as long as the penultimate joint, moderately stout and moderately curved.

Ends of the basal rays very prominent in the angles of the calyx; radials concealed; IBr<sub>1</sub> short, oblong, widely separated laterally; IBr<sub>2</sub> (ax) broadly pentagonal, about twice as broad as long.

Ten arms; first seven or eight brachials slightly wedge-shaped, then triangular about as broad as long. Arms rugged and tubercular basally, but not enlarged or swollen.

P<sub>1</sub> long, stout basally but becoming slender and flagellate distally; P<sub>2</sub> slightly smaller and slightly less stout basally; following pinnules shorter and more slender, the distal pinnules increasing to about the length of P<sub>1</sub>; comb confined to PP<sub>1, 2</sub> and <sub>3</sub>.

*Distribution*.—Only known from the Korean Straits.

*Depth*.—One hundred and seventy fathoms.

## 4. COMACTINIA, new genus.

1840. *Comatula* (part) J. MÜLLER, Archiv für Naturgesch., 1840, I, p. 311.

1841. *Alceto* (part) J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 143.

1849. *Comatula* (*Alceto*) J. MÜLLER, Abhandl. d. k. preuss. Akad., 1847, p. 250.

1878. *Antedon* (part) POURTALÈS, Bull. Mus. Comp. Zool., V, p. 214.

1881. *Actinometra* (part) P. H. CARPENTER, Bull. Mus. Comp. Zool., IX, No. 4, p. 154.

1908. *Comaster* (part) A. H. CLARK, Proc. U. S. Nat. Mus., XXXIII, p. 685.

1908. *Phanogenia* (part) A. H. CLARK, Proc. U. S. Nat. Mus., XXXV, p. 124.

*Genotype*.—*Alceto echinoptera* J. Müller, 1841.

*Description*.—Centro-dorsal rather large, discoidal, the cirri arranged in a single marginal row.

Cirri short and stout, IX–XXVII, 8–12; basal joints short, then two or three half again to twice as long as broad, the following decreasing in length, being about as long as broad distally; opposing spine, small, erect, median in position; no dorsal spines or projections; terminal claw about as long as the antepenultimate joint (which is longer than the penultimate) stout and strongly curved basally, becoming slender and nearly straight distally.

Ends of the basal rays visible in the interradi al angles; radials concealed; IBr<sub>1</sub> very short and band-like, closely united laterally; IBr<sub>2</sub> (ax) triangular, usually about twice as broad as long; IBr<sub>1</sub> and first two brachials in lateral contact, though not laterally flattened.

Ten arms; proximal brachials discoidal, or oblong, then becoming triangular, at first broader than long, later about as long as broad, and wedge-shaped terminally.

Oral pinnules longer than, but not quite so stout as, those succeeding; middle pinnules with more or less developed spinous edges and dorsal processes on the joints.

*Distribution*.—Caribbean Sea, northward to South Carolina and southward to Brazil.

*Depth*.—Sublittoral, and down to 262 fathoms.

## 5. LEPTONEMASTER, new genus.

*Genotype*.—*Leptonemaster venustus*, new species.

*Description*.—Centro-dorsal a thin flat disk; cirrus sockets in a single marginal row.

Cirri XV–XX, 12–15, long and slender; first joint short, second half again as broad as long to nearly square, third about twice as long as its terminal diameter, fourth the longest, two and one-half to three times as long as its proximal diameter, fifth a transition joint, not quite so long as the fourth, with a dark band about its center; following joints gradually decreasing in length, the antepenultimate being very slightly longer than broad, or squarish, and the



penultimate squarish or not quite so long as broad; second to sixth joints slender, moderately constricted centrally ("dice-box shaped"), with prominent articulations, rounded in cross-section, then becoming rather strongly compressed laterally (the distal portion of the cirrus therefore becoming broader in lateral view) and less and less "dice-box shaped;" transition and following joints with a small, though prominent, sharp subterminal dorsal spine; opposing spine slightly marked, median, arising from the entire dorsal surface of the penultimate joint; terminal claw somewhat longer than the penultimate joint (about as long as the antepenultimate), moderately stout, and moderately curved, the curvature being strongest in the basal portion.

Ends of the basal rays visible as rather prominent tubercles in the angles of the calyx; radials entirely hidden or slightly visible over the ends of the basal rays, separated distally;  $IBr_1$  short, nearly four times as broad as long, the proximal edge convex, not in contact basally, rounded and widely free laterally, the sides of adjacent  $IBr_1$  making with each other an angle of about  $90^\circ$ ;  $IBr_2$  (ax) triangular, the anterior angle somewhat produced, about one and one-half times as broad as long, the very short lateral edges making an obtuse angle with those of the  $IBr_1$ .

Ten arms; first seven brachials approximately oblong, then becoming obliquely wedge-shaped, and after the tenth triangular, about as long as broad, and terminally obliquely wedge-shaped and longer than broad, with somewhat expanded articulations; after about the sixth the brachials develop strongly produced and overlapping distal ends. Syzygies occur between the third and fourth brachials, again between the tenth and eleventh to twelfth and thirteenth, and distally at intervals of three oblique muscular articulations.

Disk naked; mouth and anal tube about equally eccentric.

$P_1$  the stoutest, and much the longest, evenly tapering to a flagellate tip;  $P_2$  considerably shorter and much more slender than  $P_2$ ;  $P_3$  not much more than one-third,  $P_4$  one-third the length of  $P_1$ ; following pinnules increasing slowly in length, the distal being nearly as long as  $P_1$ , with elongated joints which have expanded articulations, and spinous distal ends.

*Distribution*.—Caribbean coast of Central America, Gulf of Mexico, and northern coast of Cuba.

*Depth*.—Forty-two to 163 fathoms.

LEPTONEMASTER VENUSTUS, new species.

Centro-dorsal a thin flat disk, the small cirrus sockets arranged in a single crowded marginal row, usually five to each radial area.

Cirri XV-XX, 12-15 (most commonly 13 or 14) 10 mm. long, as described above.

IBr series and calyx elements as described.

Ten arms 70 mm. to 90 mm. long; first brachial short, slightly wedge-shaped, about three times as broad as the exterior length, entirely separated interiorly by the anterior apex of the IBr<sub>2</sub>, the interior edges diverging at an angle of approximately 90° or slightly less; second brachial irregularly quadrate, slightly larger than the first; third and fourth brachials (syzygial pair) oblong, about half again as broad as long; next three brachials approximately oblong, about twice as broad as long, then becoming obliquely wedge-shaped, and after about the tenth triangular, about as long as broad, further out on the arm becoming very obliquely wedge-shaped (almost triangular) about as long as broad, and in the terminal portion longer than broad. After about the sixth the brachials develop strongly produced and overlapping distal ends.

P<sub>1</sub> 10 mm. long, with about thirty-five joints, moderately stout basally and evenly tapering; terminal comb with 13 to 15 teeth, preceded by two or three more or less rudimentary; teeth spade-shaped or triangular, longer than broad, slightly longer than the lateral diameter of the joint which bears them, well separated, and incurved; basal joints of the pinnule broader than long, the proportionate length gradually increasing, so that the joints from the middle onward are approximately squarish; the joints have prominent dorsal projections with the apex at the distal end, and strongly produced distal edges, these characters dying gradually away after about the middle of the pinnule; P<sub>2</sub> much more slender than P<sub>1</sub>, 7 mm. long, the joints after the fifth squarish; first two joints with strong dorsal processes or broad carinations, that of the second the stronger; following joints with rounded dorsal processes and prominent distal edges; terminal comb rather long with sixteen fully developed and five or six smaller and more rounded teeth; teeth proportionately slightly longer and better developed than the teeth of P<sub>1</sub>; P<sub>3</sub> about 4 mm. long, slender and delicate, the first two joints disproportionately large, about half again as broad as long, the second with a much produced distal dorsal angle or even distal half of the dorsal side; third joint squarish; following joints slightly longer than broad; third and following joints as far as the comb, as in P<sub>2</sub>, with strongly produced coarsely spinous distal ends; comb as in P<sub>2</sub>; P<sub>4</sub> 3.5 mm. long, slightly more delicate than P<sub>3</sub>, with no enlargement of the two basal joints and no comb; first two joints short, third longer than broad, the following increasing slightly in length, being about half again as long as broad distally; third and following joints with produced and coarsely spinous distal edges; P<sub>5</sub> similar to P<sub>4</sub>, 4 mm. long, with sixteen joints, but slightly stouter; following pinnules similar to P<sub>5</sub>, increasing very gradually in length; distal pinnules 8 mm. to 9 mm. long, slender, with about 21 joints, the first two not so long as

broad, the third slightly longer than broad, the remainder becoming elongated and about three or four times as long as broad distally; third and following joints with expanded articulations and coarsely spinous distal ends.

*Color* (in spirits).—Brownish white, the perisome dark brown.

*Type*.—Cat. No. 25457, U.S.N.M., from *Grampus* station 5104, off the west coast of Florida; 51 fathoms.

### 6. COMISSIA, new genus.

1908. *Comaster* (part) A. H. CLARK, *Smiths. Miscell. Coll.* (Quarterly Issue), LII, p. 202.

*Genotype*.—*Comissia lütkeni*, new species.

*Description*.—Centro-dorsal discoidal, the bare polar area broad and flat, the cirrus sockets arranged in two closely crowded alternating rows.

Cirri XV–XXV, 16–24, resembling those of *Capillaster*; the fourth is a transition joint.

Ends of the basal rays visible as prominent tubercles in the angles of the calyx; radials very slightly visible over the ends of the basal rays, or quite concealed;  $IBr_1$  short and broad, closely united laterally, more or less concealed by the centro-dorsal;  $IBr_2$  (ax) triangular, about twice as broad as long, free laterally; synarthrial tubercles prominent.

Ten arms; first brachial short, slightly wedge-shaped, between three and four times as broad as long exteriorly, interiorly united; second brachial larger and much more obliquely wedge-shaped; third and fourth (syzygial pair) somewhat longer interiorly than exteriorly, about twice as broad as the interior length; following one or two brachials almost oblong, about three times as broad as long, then becoming triangular, about twice as broad as long, in the terminal part of the arm becoming very obliquely wedge-shaped, about as long as broad; brachials after the second with prominent and finely spinous distal ends and a very finely tubercular or spinous dorsal surface which in the terminal portion gradually become obsolete, so that the ends of the arms are practically smooth. Syzygies occur between the third and fourth brachials, again between the eleventh and twelfth to fourteenth and fifteenth, and distally at intervals of three oblique muscular articulations.

Disk naked, or with small scattered calcareous granules; mouth subcentral; anal tube small and marginal.

$P_1$  the longest; following pinnules decreasing gradually in length and slightly in stoutness to  $P_4$ , which is less than half as long as  $P_1$ , with somewhat less than half as many joints; following pinnules remaining similar for some time, then gradually becoming more slender and increasing in length to about the length of  $P_3$  distally;



the joints of the middle and distal pinnules are slightly "dicebox-shaped," with a finely spinous surface and with the distal ends produced ventrally into two long sharp spines, one on each side of the perisome; this modification of the joints in the more proximal of the pinnules affects only the distal portion, but later encroaches more and more upon the proximal part, soon involving almost all of the joints.

COMISSIA LÜTKENI, new species.

1908. *Comaster coppingeri* (part) A. H. CLARK, Smiths. Miscell. Coll. (Quarterly Issue), LII, p. 202 (ten-armed specimens).

Centro-dorsal discoidal, the bare polar area broad and flat, 4 mm. or 5 mm. in diameter; cirrus sockets arranged in two closely crowded alternating rows.

Cirri XV-XXV, 16-24 (usually 18-21) 7 mm. to 17 mm. long, comparatively small and rather stout; first joint over twice as broad as long, second and third nearly or quite as broad as long, fourth half again to nearly twice as long as broad, a transition joint, usually rather darker than the preceding, but light colored and with a polished surface in the distal fourth; following joints decreasing in length, after the eighth being about twice as broad as long; occasionally the fifth is a transition joint instead of the fourth, in which case the two are about of the same size; fourth and following joints with the dorsal and dorso-lateral distal edge everted and finely spinous; this eversion of the distal edge of the joints gradually narrows anteriorly, on the last two or three joints becoming merely a single blunt spine or tubercle; concurrently with its shortening, it gradually attains a crescentic form, so that in lateral view the joints from the fourth onward appear to be furnished with low dorsal spines which arise gradually from the whole dorsal surface, at first terminal, gradually becoming subterminal in position, and on the antepenultimate joint almost median; opposing spine median, arising from the entire dorsal surface of the penultimate joint, short and blunt, reaching not more than one-third the distal diameter of that joint in height; terminal claw about as long as the penultimate joint, stout, and moderately curved.

Post-radial elements as given in the generic description; the arms are 70 mm. to 75 mm. long.

P<sub>1</sub> 12 mm. to 15 mm. long, slightly stouter than the succeeding, though not especially large, with about thirty-five joints, at first about twice as broad as long, very gradually becoming longer and about as long as broad after the twelfth or fifteenth; terminal comb prominent, arising abruptly, with sixteen teeth, bluntly triangular, nearly twice as long as broad at the base, basally in apposition, about as high as the transverse diameter of the joints which bear them, rather strongly recurved; P<sub>2</sub> similar, 10 mm. to 12 mm. long; P<sub>3</sub>



similar, 8 mm. to 10 mm. long;  $P_4$  6 mm. long;  $P_5$  and following pinnules 6 mm. long without combs, composed of sixteen joints, the first three not so long as broad, the remainder about as long as broad; distally the pinnules gradually increase in length and become more slender, being distally 8 mm. long with twenty-three to twenty-five joints, the first two short, the third and following longer than broad, becoming about twice as long as broad in the outer portion. The lower pinnules have the corners of the joints considerably cut away as in *Heliometra*; the joints of the middle and distal pinnules are slightly "dice-box shaped" with a finely spinous surface, and with the distal ends produced ventrally into two long, sharp spines, one on each side of the perisome; this modification of the joints in the more proximal of the middle pinnules affects only the distal portion, but later encroaches more and more upon the proximal part of the pinnules, soon involving almost all of the joints.

*Color* (in spirits).—Bright yellow, the skeleton lighter.

*Type*.—Cat. No. 25513, U.S.N.M., from *Albatross* station 5153; east of Port Dos Amigos, Tawi Tawi; 49 fathoms.

#### 7. Genus CAPILLASTER A. H. Clark.

1758. *Asterias* (part) LINNÆUS, Syst. Nat., 10th ed., II, p. 663.

1772. *Asteria* (part) BRÜNNICH, Zoölogia fundamenta, p. 230 (emendation).

1816. *Comatula* (part) LAMARCK, Hist. nat. des animaux sans vertèbres, II, p. 530.

1836. *Comaster* (part) L. AGASSIZ, Mém. Soc. de sci. nat. de Neuchâtel, I, p. 193.

1841. *Actinometra* (part) J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 140.

1849. *Comatula* (*Actinometra*) (part) J. MÜLLER, Abhandl. d. k. preuss. Akad., 1847, p. 246.

1849. *Comatula* (*Alecto*) (part) J. MÜLLER, Abhandl. d. k. preuss. Akad., 1847, p. 258.

1909. *Capillaster* A. H. CLARK, Proc. Biol. Soc. Washington, XXII, p. 87.

*Genotype*.—*Actinometra sentosa* P. H. Carpenter, 1888.

*Distribution*.—Madagascar to northern Australia, the Philippines, and Japan.

*Depth*.—Littoral and sub-littoral; rarely down to 160 fathoms.

#### 8. NEMASTER, new genus.

1879. *Antedon* (part) RATHBUN, Trans. Conn. Acad. Sci., V, p. 157.

1880. *Actinometra* (part) P. H. CARPENTER, Journ. Linn. Soc. (Zool.), XV, p. 213.

1908. *Comaster* (part) A. H. CLARK, Proc. U. S. Nat. Mus., XXXIII, p. 685.

*Genotype*.—*Nemaster grandis*, new species.

*Distribution*.—Caribbean Sea and Atlantic coast of South America south to Bahia.

*Depth*.—Littoral, and down to 194 fathoms.

*Diagnosis*.—In general same as *Capillaster*; IIBr 4 (3+4); IIIBr 3 (2+3), or irregular; brachials at first oblong, then triangular, about as long as broad, wedge shaped and longer terminally; terminal comb usually repeated on inner side of proximal pinnules; side plates developed along the ambulacra.

NEMASTER GRANDIS, new species.

Centro-dorsal thick-discoidal, the polar area 5 mm. in diameter, deeply concave; cirrus sockets marginal, arranged in three closely crowded alternating rows.

Cirri XXV-XXX, 30-35, about 40 mm. long, large and stout; first joint short, about three times as broad as long; following joints gradually increasing in length to the sixth or eighth, which, with the three following, is squarish, then gradually decreasing, the joints from the twelfth or fifteenth onward being about twice as broad as long, but the last two are almost square again; a transition joint occurs between the seventh and the twelfth, proximal to which the joints have a dull, finely pitted surface, distally a highly polished surface, the pits widely scattered or absent, and dorsal projections; transition joint not especially marked; joints proximal to the transition joint with practically straight sides and no modification of the dorsal distal edge; transition and following joints with the distal dorsal edge projecting as a transverse ridge, coarsely dentate (usually tridentate), the ridge being equal in length (transversely) to about half the diameter of the joints; distally the ridge gradually narrows, becoming bidentate, and in the terminal four to seven joints resolves itself into a single spine, which on the antepenultimate becomes subterminal in position; all the transverse ridges appear as rather prominent spines in lateral view; opposing spine prominent, though short, rather stout, arising from the whole dorsal surface of the penultimate joint, about equal in length to one-third the diameter of that joint, the apex subterminal or submedian, the distal edge usually making much less of an angle with the transverse diameter of the joint than the proximal, giving the spine the appearance of leaning forward; terminal claw considerably longer than the penultimate joint, stout basally, slender distally, strongly curved proximally, but becoming nearly straight in the distal portion.

Ends of the basal rays visible as low tubercles in the angles of the calyx, but with difficulty differentiated from the adjacent parts; radials concealed in the median line, but visible as a rather prominent triangle in the angles of the calyx, the apex of which separates the lower corners of the IBr<sub>1</sub>; IBr<sub>1</sub> oblong, rounded dorsally and laterally, about three times as broad as long, widely separated laterally; IBr<sub>2</sub> (ax) pentagonal, one-third to one-half again as broad as long, the

lateral edges diverging distally and about equal in length to those of the IBr; ; IIBr 4 (3+4); IIIBr 3 (2+3), the division series being separated by a distance about equal to the breadth of the IIBr series; if the full IIIBr series is not present, those on the exterior sides of the IBr series are most frequently absent, so that there is an approximation to a 1, 2, 2, 1 arrangement.

Twenty-four to thirty-one arms, about 200 mm. long; first brachial wedge-shaped, rather large, not quite half again as broad as the exterior length, almost entirely united interiorly; second and third brachials (syzygial pair) not quite so long as broad; next four brachials oblong, about twice as broad as long, then wedge-shaped, and after three or four triangular, about as long as broad; in the terminal portion of the arms the brachials become wedge-shaped, nearly or quite twice as long as broad. The distal edges of the brachials project slightly and are beset with fine spines. Syzygies occur between the second and third brachials, again between the fourteenth and fifteenth to twenty-second and twenty-third (usually in the vicinity of the eighteenth) and distally at intervals of three oblique muscular articulations.

Mouth marginal and radial; anus central; disk naked, about 30 mm. in diameter; side plates developed along the brachial and pinnule ambulacra.

$P_D$  30 mm. to 35 mm. long, stout, much stouter than the succeeding pinnules, but tapering evenly to a slender and flagellate tip, with forty to forty-five joints, all of which are approximately squarish; a slight prominence is visible on the dorsal side of the distal edge of the second joint, which rapidly becomes larger and increases in width on the succeeding joints, after about the seventh taking the form of a strong coarsely spinous eversion of the dorsal edge of the joints; this disappears near the proximal part of the distal comb; comb composed of fourteen teeth, arising abruptly; first tooth low and triangular; second oblong or slightly trapezoidal, usually slightly broader basally than high, the following becoming more obliquely trapezoidal and relatively somewhat higher, the terminal teeth being truncated-triangular; the more proximal teeth are not equal in height to more than three quarters of the lateral diameter of the joints which bear them, but the later teeth, owing to the distal tapering of the pinnule, become about equal to the lateral diameter;  $P_P$  about 25 mm. long, considerably less stout than  $P_D$ , but otherwise similar to it;  $P_1$  about 20 mm. long, much less stout than  $P_P$ , similar to it;  $P_2$  and following pinnules slender and delicate, about 10 mm. long;  $P_2$  bears a comb distally, but the following pinnules are without combs;  $PP_{2, 3, 4}$ , and  $a, b, c$  have the first two joints disproportionately large and produced dorsally into large carinate processes; distal pinnules slender, about 12 mm. long, with about twenty-five



joints, the first over twice as broad as long, the second about as long as broad, the third longer than broad, the remainder about half again as long as broad. The distal ends of the joints are slightly everted and finely spinous; the dorsal surface is beset with fine spines, and the last four joints bear long recurved spines.

*Type*.—Cat. No. 25459, U.S.N.M., from *Albatross* station 2146; off Colon; 34 fathoms.

#### 9. Genus COMATELLA A. H. Clark.

1874. *Actinometra* (part) LÜTKEN, Mus. Godeffr. Cat., V, p. 190.

1908. *Comaster* (part) A. H. CLARK, Proc. U. S. Nat. Mus., XXXIII, p. 685.

1908. *Phanogenia* (part) A. H. CLARK, Proc. U. S. Nat. Mus., XXXV, p. 124.

1908. *Comatella* A. H. CLARK, Smiths. Miscell. Coll. (Quarterly Issue),

LII, p. 207.

*Genotype*.—*Actinometra nigra* P. H. Carpenter, 1888.

*Distribution*.—Ceylon to Fiji, Tonga, Samoa, and Japan; West Indies, St. Paul's Rocks, Atlantic coasts of southern Europe and northwestern Africa.

*Depth*.—In the Indian and Pacific oceans, littoral, and down to 140 fathoms; in the Atlantic 73–830 fathoms.

#### 10. Genus COMASTER L. Agassiz.

1816. *Comatula* (part) LAMARCK, Hist. nat. des animaux sans vertèbres, II, p. 530.

1836. *Comaster* L. AGASSIZ, Mém. Soc. de Sci. nat. de Neuchâtel, I, p. 193.

1841. *Alecto* (part) J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 147.

1849. *Comatula* (part) J. MÜLLER, Abhandl. d. k. preuss. Akad., 1847, p. 262.

1866. *Phanogenia* LOVÉN, Öfversigt k. Vetensk.-Akad. Förhandl., 1866, No. 9, p. 231.

1879. *Actinometra* (part) P. H. CARPENTER, Proc. Roy. Soc., XXVIII, p. 386.

*Genotype*.—*Comatula multiradiata* Lamarck, 1816 (not *Asterias multiradiata* Linnæus) = *Alecto multifida* J. Müller, 1841.<sup>a</sup>

*Distribution*.—Northern Australia to Luzon and the Mergui Archipelago.

*Depth*.—Littoral and sublittoral.

#### 11. Genus COMANTHUS A. H. Clark.

1816. *Comatula* (part) LAMARCK, Hist. nat. des animaux sans vertèbres, II, p. 530.

1841. *Actinometra* (part) J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 140.

1841. *Comaster* (part) J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 140.

1841. *Alecto* (part) J. MÜLLER, Archiv für Naturgesch., 1841, I, p. 144.

1849. *Comatula* (*Actinometra*) (part) J. MÜLLER, Abhandl. d. k. preuss. Akad., 1847, p. 256.

<sup>a</sup> Cf. Proc. Biol. Soc. Washington, XXII, p. 87.



1849. *Comatula (Alecto)* (part) J. MÜLLER, Abhandl. d. k. preuss. Akad., 1847, p. 260.  
 1891. *Goldfussia* (not of de Castelnau, 1843) NORMAN, Ann. and Mag. Nat. Hist., [6] VII, p. 387.  
 1908. *Phanogenia* (part) A. H. CLARK, Proc. U. S. Nat. Mus., XXXV, p. 124.  
 1908. *Comanthus* A. H. CLARK, Proc. Biol. Soc., Washington, XXI, p. 220.

*Genotype*.—*Comanthus intricata* A. H. Clark, 1908.

*Distribution*.—South Africa westward and northwestward, along the southern coast of Asia and the entire coast of Australia, throughout the East Indies, to southern Japan, the Kingsmill (Gilbert) Islands, Fiji, and Samoa.<sup>a</sup>

*Depth*.—Littoral and sublittoral.

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<sup>a</sup> Carpenter records *C. rotalaria* ("*Actinometra parvicirra*") from Peru, in South America, and others have since accepted this record. This Peru is, however, undoubtedly Peru or Francis Island, situated approximately in lat. 1° 30' S., long. 176° 00' E., in the Gilbert group, north of Fiji.



## A NEW SQUIRREL FROM DIRECTION ISLAND, SOUTH CHINA SEA.

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By MARCUS WARD LYON, Jr.,

*Second Assistant Curator, Division of Mammals, U. S. National Museum.*

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On his way to Borneo, in 1907, Dr. W. L. Abbott stopped for a day at Direction Island, where he secured a single specimen of the new species of plantain squirrel described below. Direction Island, also called Pulo Mankotan and Pulo Pengiki Kichil (or Paneeky Ketchil), lies in the South China Sea in latitude  $0^{\circ} 14' 39''$  north and longitude  $108^{\circ} 1' 53''$  east. Politically and geographically it is a member of the Tambelan group, of which it is the most southeastern. An account of the mammals of this group and of some adjacent islands was published by Mr. Gerrit S. Miller, jr.,<sup>a</sup> in 1900.

Doctor Abbott says of the island: "It is about three-fourths mile long by about one-fourth mile wide, and 500 to 600 feet high. The surface is rocky, but covered with trees except at the southwest corner, where a clearing has been made by the Orang Laut, who occasionally visit the island. Here a few cocoanuts have been planted, also some bananas and papaya. A number of squirrels were heard, but only two were seen, of which one was shot. No other mammal was seen, although there were doubtless rats. There were many white fruit pigeons. Turtles had been laying their eggs on the sand beach, where there were also many tracks of *Varanus* lizards."

SCIURUS DIRECTOR, new species.

*Type*.—Skin and skull of an immature (large permanent upper premolar just displacing the milk tooth) male, Cat. No. 145392, U.S.N.M., collected on Direction Island, South China Sea, May 1, 1907, by Dr. W. L. Abbott. Original number, 5152.

*Diagnostic characters*.—A "red"-bellied member of the *vittatus* group characterized by a more ruddy cast to the entire pelage than usual.

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<sup>a</sup> Mammals collected by Dr. W. L. Abbott on islands in the South China Sea, Proc. Wash. Acad. Sci., II, pp. 203-246, August 20, 1900.

*Color*.—Upper parts of head and body, a fine grizzle of black and ochraceous or ochraceous-buff, both colors about equally mixed, the ochraceous being somewhat paler over the shoulders than elsewhere, and darkest posteriorly and in the region of the thighs; upper surface of the tail very similar to upper surface of head and body in color, but the grizzling is coarser and in certain lights the tail appears finely annulated; outer sides of thighs and arms similar to back, but with finer grizzling and the ochraceous predominating; upper surfaces of feet dull ochraceous darkened by the blackish bases of the hairs showing through; light side-stripe, about 55 by 5 mm., between buff and ochraceous-buff; dark side-stripe, about 50 by 7 mm., blackish finely sprinkled with ochraceous-buff; underparts and inner side of fore and hind legs a color something between Ridgway's ochraceous-buff and ochraceous-rufous; underside of tail a very coarse grizzle of blackish and ochraceous, the latter color predominating in the middle line; inner side of ears and an orbital ring, the lower half of which is most pronounced, ochraceous-buff; outer side of ears similar to adjacent parts of head; cheeks and base of whiskers similar to rest of head, but grizzle very fine and the ochraceous-buff predominating.

*Skull and teeth*.—These show no special peculiarities; the audital bullæ and teeth, however, are smaller than they are in the majority of species of squirrels of the *vittatus* group.

*Measurements*.—External measurements taken by collector: Head and body, 190 mm.; tail vertebrae, 182; hind foot, with claws, 49. Cranial measurements: Greatest length, 46.4; basal length, 39; zygomatic breadth, 26.7; interorbital constriction, 16; mandible, front of symphysis to back of condyle, 29.5; maxillary tooththrow (alveoli), 9.2; mandibular tooththrow (alveoli), 8.7.

*Specimens examined*.—One, the type.

*Remarks*.—Compared with its geographical neighbor, *Sciurus abbottii* Miller,<sup>a</sup> of Big Tambelan Island, *S. director* is conspicuously more ruddy throughout, being ochraceous or ochraceous-rufous where *S. abbottii* is only buffy or ochraceous-buff. Among the forms of the *S. vittatus* group of squirrels in the National Museum *S. tedongus* Lyon,<sup>b</sup> from the island of Banka, most nearly resembles *S. director*, but is less ruddy, except on the belly, which has about the same color in the two species.

<sup>a</sup> Proc. Wash. Acad. Sci., II, p. 224, August 20, 1900.

<sup>b</sup> Proc. U. S. Nat. Mus., XXXI, p. 591, December 18, 1906.



# THE THORAX OF INSECTS AND THE ARTICULATION OF THE WINGS.

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## I. INTRODUCTION.

This paper is an attempt to show the unity of thoracic structure that prevails throughout all the orders of insects. It is hoped that it will be of special service to systematists in entomology and that it will meet with approval from students of morphology. The material on which the paper is based was all drawn from the U. S. National Museum and the dissections have been deposited in the museum.

The work has been done under the direction of Dr. A. D. Hopkins, of the U. S. Bureau of Entomology, and has grown from an attempt to determine thoracic homologies in the Coleoptera, especially in the family Scolytidae. It is published by the approval of Dr. L. O. Howard, chief of the bureau, as a contribution from the office of Forest Insect Investigations. The author is indebted to Doctor Hopkins not only for the opportunity of carrying on the work but also for a great deal of help in doing it and for the verification of observations. Assistance has also been received from other members of the entomological staff of the bureau, among whom are Mr. Nathan Banks, Mr. A. N. Caudell, Mr. D. W. Coquillett, Mr. R. P. Currie, Dr. H. G. Dyar, Mr. Otto Heidemann, Mr. E. A. Schwarz, and Mr. H. S. Barber and also Mr. J. C. Crawford, of the U. S. National Museum.

Some of the drawings on the plates were used by the writer in a former paper on the thorax, published in the Proceedings of the Washington Entomological Society (1908), and are here reproduced with the permission of the editors of that journal.

No new theory is presented. The writer claims that the diagrams forming text figures 1 to 6 represent simply the facts. All schemes of thoracic symmetry in consecutive circles are discarded on the ground that they are supported only by the imagination.

The following statements sum up the principal conclusions: (1) There is no reason for believing that the parts of any thoracic segment are derived from more than one metamere, though the primitive thoracic region may have been composed of more than three segments, remnants of the supernumerary ones being possibly represented by the intercalary plates of some of the Aptera; (2) the thoracic sclerites are subdivisions of an original undivided segmental wall; (3) the sclerites of the pleurum are homologous throughout all the orders and modifications are brought about principally through the coalescence of the pleurites; (4) the tergum consists of a primitive undivided notal plate carrying the wings and, in the adult meso- and metathorax of all the principal orders, except the Orthoptera, of a second postnotal or pseudonotal plate developed in the membrane behind the first and having no connection with the wings; (5) the divisions of the notum are secondary, though similar in most of the orders, and are not necessarily homologous, while modifications are brought about through a stronger subdivision into distinct regions and even into separate sclerites.

It is unfortunate for modern entomology that there are so many species of insects. Entomologists early had to specialize as Coleopterists, Dipterists, Lepidopterists, and so in each order a scheme of anatomy and a nomenclature grew up which satisfied the needs of the worker in that order but had no necessary connection with those of workers in other groups. It is true that Andouin in 1824 worked out a system of comparative external anatomy and proposed a universal set of names for the sclerites. It is true also that his names have been in large part employed by nearly all subsequent entomologists. But in the actual application of Andouin's names to the sclerites of the thorax, specialists in the various orders have differed widely on account of their ignorance concerning the correspondence of parts in different insects. Recent entomologists who have attempted to enforce a uniformity of nomenclature based on a more thorough knowledge of insect structure are confronted with the nonconforming masses of literature which must form the basis of work by present and future students in each order. However, even if systematists never can employ a uniform system of names, it can not be denied that it is best to know the true homology of the parts as far as this can be determined.

It is impossible to follow the rule of priority in selecting anatomical terms, for the name must be descriptive of the part to which it is applied. The earlier entomologists also paid little attention to the duplication of parts in successive segments, but gave a separate name to every piece. Andouin did away with this system in 1824 and firmly established a nomenclature based on the belief that each thoracic segment is a modification of one plan of structure. He

should be taken as the Linnaeus of thoracic nomenclature, and there is not sufficient reason on any ground for applying new terms to the parts he named.

In the study of the wings the venation nomenclature established by Comstock has been adopted. No attempt has been made to prove or to disprove Comstock's interpretations of the veins in the main part of the wing. While a study of the basal structure may show definitely that some particular vein is absent as a distinct trunk at the base, it still remains an open question whether this vein is actually gone or is fused with the one before or behind it. The general venation must furnish the evidence in most such cases.

## II. THE SEGMENTATION OF THE HEAD AND BODY.

A few decades ago an insect was defined as a creature consisting of a head, a thorax subdivided into three segments, and an abdomen composed of 10 or 11 segments. Such a definition, however, would not satisfy the demands of most present-day entomologists, and it is interesting to contemplate the shock some antievolutionary forefather of entomology would receive could he now see in print the statement that an insect is composed of 40 segments. This said forefather might be in some measure pacified, however, were he to learn that the insects themselves have not been required to keep pace with the ideas of entomologists concerning them.

### 1. SEGMENTATION OF THE HEAD.

If the question as to how many embryonic metameres form the head of an insect could be decided by a vote among present and past students of the subject, the six-segment theory would undoubtedly be established. The problem of head segmentation has been attacked from both an anatomical and an embryological standpoint, but, since the embryologists attempt to discover the actual facts of development, it would seem that deference should be paid to their opinions. Furthermore, the embryologists agree more closely among themselves than do the anatomists. Although the number of head metameres claimed by the former varies from four to seven, this discrepancy is not what it appears to be in figures, for the chief point of disagreement is whether the three preoral segments apparent in the embryo are actual metameres or are only secondary divisions. The real question is thus reduced to one between six and seven segments.

On the other hand, the anatomists describe from four to nine segments without any alleviating circumstances. The number of theories seems to agree closely with the number of theorizers. Comparative anatomy as a key to morphology has been so thoroughly deposed in vertebrate craniology that we must regard it with great suspicion in



entomology. On the other hand, its advocates may, of course, point out that adult insects are so specialized that even the embryo in many respects does not repeat phylogeny. Yet it has never been shown that the head is a case in point. It certainly at an early embryonic stage consists of a series of segments and no evidence has been offered to prove that these embryonic segments are not true metameres.

The principal anatomists who have mapped out the head on purely anatomical grounds are Newport (1839), Janet (1899, 1900), and Verhoeff (1905). Newport went at the subject in the simplest manner possible. He virtually drew circles around the head corresponding with the plates of the dorsal surface, namely, (1) the labrum, (2) the clypeus, (3) the front (clypeus posterior), (4) the small sclerites sometimes found about the bases of the antennæ, and (5) the epicranium. He thus had five segments which were composed laterally and ventrally by whatever fell between two of the inclosing lines.

Later anatomists have not been satisfied with this direct and simple arrangement by Newport. Janet (1899, 1900) makes out nine head segments which he arranges in three sets of three each and then points out the nice conformity in which the set of three thoracic segments follows. He does not even intimate, however, by what natural law the head should be a multiple of the thorax, or why his theory should be more plausible by making it such.

Verhoeff (1905) discredits embryology as a guide in the study of the morphology of the insect head, and, on purely anatomical grounds, elaborates a scheme of eight segments for the head of the Dermaptera. The labrum, the clypeus, and the front, according to his plan, are the first three terga, while the sterna of these segments form the epipharyngeal membrane and the anterior part of the throat. These segments constitute the "protocephalon." Following them are an antennal segment (a preantennal segment being absent in Dermaptera), and a premandibular segment, constituting the "deutocephalon." Finally, the three jaw segments form the "tritocephalon." The mentum and submentum form the sterna of the labial and maxillary segments, respectively. This view assumes that the maxillæ originate *behind* the labial palpi. In the Chilopoda the so-called maxillæ are much more like the ligula and labial palpi of insects than like the insect maxillæ, while the chilopod labium consists principally of the leg-like palpi, thus suggesting that the hexapod first maxillæ are the chilopod second maxillæ. If this should be true, then the theory advanced by Banks (1893) that the poison fangs have coalesced with the second maxillæ in Chilopoda to form the first maxillæ of Hexapoda appears more possible. Otherwise, Banks had to assume that the poison claws moved forward past the bases of the second maxillæ and then fused with the first maxillæ. A combina-



tion of the poison claws and the labial palpi of the chilopods would form an organ much more nearly resembling the insect maxillæ than would a union between the poison claws and the first maxillæ of chilopods.

All reasoning of this fascinating sort, however, simply shows the limitless extent to which morphological theorizing can be carried on anatomical grounds.

Verhoeff's theory of head segmentation has been severely criticised by Heymons (1905) on the ground that the facts of embryology utterly refute it, and that it does not conform with the segmentation of the nervous system.

The simplest embryological view holds that there are four segments in the head—a preoral, a mandibular, a maxillary, and a labial segment. This is advocated by Lowne (1892), who regards the three embryonic divisions of the preoral region as secondary. Bengtsson (1897, 1905) adopts this view concerning the preoral region, but he finds four segments in the postoral part of the head. Almost all students of the embryology of the insect head, however, regard the three preoral divisions as true metameres. Hence, embryologists are divided in opinion mainly between six and seven head segments. The principal advocates of six segments are Zaddach (1854), Huxley (1878), Viallenes (1887), Wheeler (1893), Heymons (1895), Packard (1898), Riley (1904), and Holmgren (1904, 1907). The advocates of seven head segments are Folsom (1899, 1900) and Comstock and Kochi (1902). But these authors are supported also by Bengtsson (1897, 1905) and by Börner (1904) in so far as they find four postoral segments, though they recognize only one preoral segment.

The seven-segment theory is based mainly on Folsom's (1900) observation that seven pairs of ganglia appear in the head soon after involution, and that in *Anurida maritima* a pair of appendages or "superlinguæ" appear back of the mandibles, corresponding with the fourth pair of ganglia. These appendages fuse in most insects with the lingua of the embryo to form the hypopharynx of the adult, but in many lower forms they remain as the lateral lobes of the hypopharynx or "endolabium" and have been misleadingly called the "paraglossæ." Börner (1904) finds that the hypopharynx of nearly all insects having incomplete metamorphosis is a compound structure formed of the median "glossa" and the lateral paired elements, which he calls the "maxillulæ." (The reader must remember that the terms "glossa" and "paraglossæ" have been inconsiderately applied by some recent entomologists to the parts of the hypopharynx or "endolabium," while they properly belong to the outer or true labium.) Börner thus recognizes four postoral segments. Hansen (1893) suggested that the "paraglossæ" (superlinguæ, maxillulæ) of

*Machilis* are homologous with the first maxillæ of Crustacea, and Folsom concurs in this view. Apparently no one has compared them with the paragnatha of Crustacea.

Holmgren (1907), on the other hand, claims that these superlingual processes arise from the premandibular segment and are innervated from the tritocerebrum. It would seem that he must refer to a different pair of appendages, namely, the second antennal rudiments or "intercalary appendages." His observations were made on a fly larva (*Phalacroceræ*).

Bengtsson (1897, 1905), however, describes an endolabium in *Phalacroceræ* which includes "paraglossæ," equivalent to the superlinguæ of lower insects. Holmgren (1907) refutes this idea entirely, and claims that Bengtsson's so-called endolabium of fly larvæ is not the endolabium of lower insects but simply the terminal lobes of the ordinary outer labium, of which Bengtsson's "ectolabium" is the mentum and submentum. He furthermore asserts that what Bengtsson takes for nerves going to this endolabium from the superlingual ganglion are simply muscle fibers, though Bengtsson (1905) had stoutly defended his former observations (1897).

The best summarized statement of the segmentation of the head is that made by Comstock and Kochi (1902). Although some work has been done since, but little new information has been added. The preoral part of the head consists of three embryonic segments corresponding with the three lobes of the brain, namely, the protocerebrum, the deutocerebrum and the tritocerebrum. The first segment has no appendages, but it innervates the eyes; the second is the antennal segment; the third carries the "intercalary appendages"—vestigial organs observed by many embryologists in the Aptera (Wheeler 1893, Uzel 1897, Claypole 1898, Folsom 1900), possibly in the Diptera (Holmgren 1907), and in the Hymenoptera (Bütschli 1870). These rudimentary appendages correspond with the second antennæ of Crustacea.

The postoral region of the head and the mouth parts are certainly derived from at least three embryonic segments, or, according to many embryologists, from four. The first is the mandibular segment. The possible second is the one under dispute, but so many embryologists have described two small appendages back of the mandibles which fuse with the median lingua to form the hypopharynx that their existence can not be doubted, and it is reasonable to suppose they represent a segment. Riley (1901), however, shows that these superlingual appendages, or maxillulæ, are absent in the embryo of *Blatta*, and he doubts that they are actual appendages where observed. Berlese (1906) also does not recognize a superlingual segment. Following this doubtful metamere is the segment of the first maxillæ, and finally that of the second maxillæ or labium.

Comstock and Koechi (1902) attempt to assign the various head sclerites of the adult to individual segments of the embryonic head. Riley (1904) in studying the cockroach arrives at different results, but he discredits the reliability of all attempts to map out the adult head according to segments. In discussing Comstock's view, he says: "My results have convinced me that so intimate a relation between primary segmentation and the sclerites can not be shown."

Of course, the ventral part of the preoral region becomes dorsal so that the mouth, which is originally on the middle of the ventral surface of the head, comes to be situated anteriorly. Thus the labrum, clypeus, and front are developed from a primitive ventral surface. So, in a general way, the other sclerites arise from definite regions, but they are simply secondary divisions of a continuous head capsule, and the notion that they are modified terga, pleura, and sterna of the head metameres appears to be entirely unsupported by actual evidence.

The last head segment is the one that chiefly concerns us in a study of the thorax. All embryologists seem to agree that its body forms the sclerites found in the neck of the adult and that only its fused appendages, the labium, become associated with the head, except when there is a gular plate present, which sclerite is derived from its sternum. This embryonic segment can, therefore, hardly be spoken of as a head metamere. It is the segment of the neck and this, in the adult, has received the name of "microthorax."

Hence we would accept six primitive head segments, providing the apparent superlingual segment is a real one, and one microthoracic or neck segment.

## 2. SEGMENTATION OF THE BODY.

The foregoing discussion of the segmentation of the head has been made more extensive, perhaps, than a mere introduction to the study of the thorax would require. But the writer wishes to illustrate to anyone not familiar with the subject the utter futility of attempting a study of metamerism on an anatomical basis. The embryology of the thorax has never brought out much more than that three segments compose it, except in the Hymenoptera, where the first abdominal segment is fused with the thorax. Hence there are no embryological facts concerning the thorax by which anatomists can be held in check, but, with the unfortunate example of both the vertebrate and the insect head in mind, one must certainly regard with much doubt all theories of thoracic metamerism based on a study of the plates forming the very apparent three segments in the adult. Riley (1904) makes the following appropriate statement:

It would seem that the definitive sclerites can afford little or no evidence as to the primary segmentation of insects. This is certainly true of the head sclerites



and I see no reason why it should not apply to other regions of the body. Sclerites originate from mechanical causes and do not necessarily have any relation to the primary segmentation.

Lowne (1892) in discussing the prevalent notion of the dual structure of the thoracic segments states that he does not admit it proved, and does not see that it helps in the understanding of the morphology of the insect segment.

The writer, then, wishes to say emphatically that he discards everything but plain statements of the facts in the description of the thorax. Since, however, modifications of the same plan of thoracic structure recur throughout the insect orders, this fact can be taken as evidence that all the sclerites, especially those of the pleurum, have not been produced independently in the different orders.

Many writers have supposed that each thoracic segment consists of two united segments. The arrangement of the plates on any typical segment would suggest this—the dividing line on the side passing between the episternum and the epimerum, on the back between the scutum and scutellum, and on the venter between the sternum and sternellum. Some authors have adduced further evidence of the dual nature of the segment from the apparent division of the coxa in some orders into an anterior and a posterior part.

Banks (1893), arguing from the coalescence of segments in the Chilopoda, concluded that the thorax of insects is formed of five segments, the first, third, and fifth retaining the legs, the second and fourth bearing the wings. He regards the coxæ as double and cites the meso- and metacoxal appendages of *Machilis* as examples of remnants of the ventral appendages of segments two and four. He points out that in *Scutigera* (the highest chilopod) the small terga, after the first segment, are united with the larger ones so that the first segment bears only one pair of legs while the following bear two pairs each. It is only a step from this to suppose that in *Machilis* the second leg of each pair has become rudimentary, forming the coxal appendages, while the first of each pair has persisted as the functional walking appendage. Banks does not seem to regard the cervical sclerites of insects as representing a segment in the thoracic series.

Patten (1890) gave other reasons for regarding each segment as double, adduced from a study of the mouth parts and the nerves.

Walton (1900) still further supports this theory by a study of the coxæ. He concludes that in both the Chilopoda and the Hexapoda the coxa is composed of an anterior part, "coxa genuina," and a posterior part, "coxa meron." These two coxal segments falling in line with the episternum and epimerum, and the arrangement of the thoracic muscles, form his basis for believing the entire segment a compound of two primitive segments.



Now, it is only in the mesothorax and metathorax of Mecoptera Neuroptera, Trichoptera, and Lepidoptera that the coxa is actually a double structure. In these orders the coxa genuina of Walton carries the trochanter, while the coxa meron is attached to the coxa genuina only. In other orders in which the coxa shows a more or less evident division this division is in the coxa genuina itself, the coxa meron being absent, and is of the nature of a strengthening of the coxa by opposite ridges on its inner walls. In the Neuroptera and Trichoptera at least it can easily be demonstrated, by a study of larval and pupal forms, that the "coxa meron" is simply a detached extension of the epimerum, which fuses upon the posterior side of the true coxa. It is, hence, not a part of the primitive coxa at all, and the apparent double coxa in these orders is a purely secondary condition. (See special descriptions under Neuroptera, p. 564, and Trichoptera, p. 565, also p. 542 and figs. 144-148.)

Comstock and Kochi (1902) show that the plates of each segment may be arranged into two subsegments, but defer any opinion as to whether they represent two primitive segments or not.

It will be found that all these theories are purely imaginative. Embryologists have not shown that the plates of any thoracic segment are derived from more than one metamere. However, it may be true that two, three, or four segments primarily existed where there is but one in insects as we now know them. Verhoeff (1902, 1903, 1903a, 1903c, 1904, 1904a) is the principal elaborator of this theory.

Verhoeff bases his ideas on a study of the Aptera, the Embiidæ, and the Dermaptera, and especially on a comparison of *Japyx* with the Chilopoda. He first points out the tendency in the Chilopoda toward the suppression of every alternate segment by a fusion with the preceding larger spiracle-bearing segment. In *Japyx* there are remnants of extra segments between the pro- and mesothorax, and between the meso- and metathorax, represented principally by well-developed tergal and sternal plates. Thus the thorax would consist of six segments in three pairs, namely, the microthorax and prothorax, the stenothorax and mesothorax, and the cryptothorax and metathorax. Verhoeff observes, however, that this arrangement does not correspond with that of the Chilopoda, because the small segment in *Japyx* is associated with the large segment following instead of with the one preceding. Then, as if to remedy this discrepancy, he further discovers traces of still other thoracic segments, one between the stenothorax and the mesothorax and another between the cryptothorax and the metathorax. Finally, by the aid of small presternal plates ("vorplatten") he is able to construct the following table of complete uniformity in segmentation between Scolopendridæ and Japygidæ (Verhoeff, 1904a):

## SCOLOPENDRIDÆ.

Head.  
 Maxilliped segment.  
 First leg-bearing segment.  
   Intercalary segment.  
 Second leg-bearing segment.  
   Intercalary segment.  
 Third leg-bearing segment.  
   Intercalary segment.  
 Fourth leg-bearing segment.  
   Intercalary segment.  
 Fifth leg-bearing segment.  
   Intercalary segment.

## JAPYGIIDÆ.

Head.  
 Microthorax.  
 Prothorax.  
   Presternal plates (vorplatten).  
 Stenothorax.  
   Small intercalary ring.  
 Mesothorax.  
   Presternal plates (vorplatten).  
 Cryptothorax.  
   Small intercalary ring.  
 Metathorax.  
   Presternal plates (vorplatten).

Thus, it is supposed that *two pairs* of Scolopendrid segments—a leg-bearing and an intercalary segment in each pair—have been reduced to *one segment* in ordinary insects. This reduction has resulted not from a combination of segments but from a suppression first of the intercalary segments of the chilopod and then of the alternate remaining leg segments. The intercalary segments of Scolopendridæ, in other words, are not the small segments of *Japyx*, but are the much more rudimentary traces of segments between these and the large segments. Verhoeff's own statement (1903c) is as follows:

The intermediate segments (zwischen-segmente) of insects are reduced primary segments, inherited from Chilopodan ancestors and which have united into a double segment with the large primary segment immediately behind, while the intercalary segment of the original double segment of the Chilopods has become almost entirely extinct.

According to this theory, then, the primitive thorax consisted of ten segments. However, all but three of these have been eliminated in all but the very lowest insects, and the eliminated segments have taken no part in the formation of the plates of the body wall in present-day insects. It is certainly no difficult matter to show that the sclerites are formed during postembryonic growth and are purely secondary divisions of the body wall of one segment. Hence, this theory of Verhoeff's is entirely tenable, since it deals only with conditions which are presumed to be obliterated before the thoracic plates begin to form.

However, it must be admitted that all this elaborate scheme is based on an excessive use of the imagination. No proof is adduced to show that the intermediate and intercalary sclerites of *Japyx* are not secondarily developed plates or even subdivisions of the principal segments. Desguin (1908), in reviewing this notion of the multiple nature of the thorax in Aptera, concludes that neither the anatomical nor the embryological evidence is sufficient to prove whether these intermediate sclerites represent true segments or not. Börner (1903) also gives a good criticism of some of Verhoeff's extravagant theories.

Verhoeff extends his view of the many-segmented structure of the insect body to the abdomen (1903a, 1903c, 1904). Here he finds, in the region of the first seven ordinary segments, seven primary segments and seven secondary ones. Beyond these are two genital segments, then the segment carrying the cerci, and finally, in the lowest insects, traces of three more beyond the last—the pygidium, the metapygidium, and the telson. The gonapophyses and the cerci are carried by the fifteenth, sixteenth, and seventeenth primitive segments, which are the eighth, ninth, and tenth persisting segments. Verhoeff thus makes out a total of twenty abdominal segments. Add to these the ten thoracic segments, one microthoracic segment, and nine head segments, and an insect assumes the dignity of a creature of forty segments!

### III. THE MICROTHORAX.

Embryologists have shown that the sclerites of the neck, the second maxillæ of the head, the hind part of the subœsophageal ganglion, and the gular plate, when present, are all derived from one metamere. They usually reckon this metamere as the last segment of the head, while anatomists call its cervical parts in the adult the *microthorax*. This term has become pretty well established and will be adopted in the present paper, but not implying that it is a part of the true thorax. On the other hand there is no reason for calling it a head segment. In many of the lower insects its appendages, the second maxillæ or labium, are not attached to the head but are suspended from the gular membrane and associated much more closely with the microthoracic sclerites than with the head (*Spodromantis*, 25, *Sm.*). The fact that the microthoracic ganglion is fused with the true head ganglia preceding it signifies nothing more than does the fusion of the first abdominal ganglion with that of the metathorax. It is only when the sternal plate becomes transferred to the ventral surface of the head, as the gula, that the microthorax takes any part in the actual formation of the head.

Verhoeff (1902) regards the segment of the maxillipeds or poison claws in the Chilopoda as the equivalent of the microthorax in insects. This, however, is denied by Silvestri (1902), who says that the maxilliped segment of the Chilopoda is the prothorax of insects. Verhoeff (1903b) then further shows that in *Scolopendra* there are four pairs of nerves going to this segment, of which the second is the largest and innervates the appendages. In *Polyspilota striata*, a Mantid, he discovers the same four pairs of nerves arising from the subœsophageal ganglion back of the labial nerves and going to the microthorax and salivary glands. Here, however, the second is the weakest and obviously because there are, according to Verhoeff's view, no microthoracic appendages, the labium not being regarded as such.



There is evidently a lack of harmony here unless it be that the first maxillæ of the Chilopoda correspond with the superlinguæ of the Insecta, the second maxillæ with the maxillæ, and the poison claws with the labium. In this case we could regard the microthorax of insects as the maxilliped segment of the Chilopods, which, from superficial appearances, would not seem impossible.

The sclerites of the microthorax are well known. They have been studied extensively by Verhoeff (1902) and occur in nearly all the orders of insects. They are specially well developed in the Odonata (5, 6, 7, 8, 9, 12, *Mi* and 1 *mi*, 2 *mi*, 3 *mi*, 4 *mi*), in the Orthoptera (24, 25, 36, 37, 45), and in the Euplexoptera (93), but occur in a more reduced condition in many of the other orders, such as the Coleoptera (95, *Mi*) and the Diptera (174, *mi*, *mi*). In the Orthoptera and Euplexoptera they often form an almost complete segment presenting tergal, pleural, and sternal plates. Verhoeff has gone so far as to identify all the pleurites of a thoracic segment in the microthorax, but undoubtedly this is establishing homologies on a too imaginative basis. Comstock and Kochi (1902) regard the gular sclerites of the head as the microthoracic sternum, and in some of the Euplexoptera (93) the microthoracic sternites are so large and so associated with the head as to suggest the gular sclerite of the Coleoptera.

We may conclude that there is no reason for regarding the microthorax as anything more than the neck segment whose sclerites are reduced to the small neck sclerites and the gular plate when the latter is present, whose ganglion has fused with the last head ganglion, and whose fused appendages become attached to the head in most cases and constitute the labium. It should not be included, in reckonings of the number of segments forming the head, as one of the head segments. (See note on page 595.)

#### IV. THE THORAX.

In a former paper (1908) the writer gave a brief account of the structure of the insect thorax. This description can now be amplified by illustrations taken from all the principal orders. For convenience the subject will be divided under three heads, namely, (1) the tergum, (2) the pleurum and coxa, and (3) the sternum.

##### 1. THE TERGUM.

The word *tergum* is here used to designate all the chitinized parts of the dorsum of any segment. It is generally used interchangeably with the term "notum," but where the tergum consists of two plates the latter name, *notum*, will be restricted in this paper to the first or wing-bearing sclerite, and the term *postnotum* or *pseudonotum* (Verhoeff, 1903) applied to the posterior or post-alary plate. The notum is the plate which, by diversities of its surface topography,



becomes divided into the more or less definite regions usually called the *prescutum*, *scutum*, and *scutellum*, while the postnotum remains undivided and is the *postscutellum*. The postnotum does not occur in the Orthoptera; it does not occur in the nymphs of any insects, even though well developed in the adults; it does not occur in the pupæ of Neuroptera and Coleoptera at least; and it is never present in the prothorax. Therefore it is most probably not a primitive tergal plate, and the term *pseudonotum* fits it very well. Verhoeff (1903) gave this name to the postnotal plate of the Euplexoptera (Dermaptera), though he may not have intended its general use in the sense here applied.

Text figures 1 and 2 diagrammatically represent the relation of the notum (*N*) and the pseudonotum (*PN*) to each other and to the wing, the last being carried entirely by the notum. Fig. 3, representing a segment in side view, shows the pseudonotum continuous laterally with the epimeron (*Epm*). This is the most frequent condition, though often there is a line between the two and sometimes they are only articulated or merely contiguous.

This figure and figure 2, giving a ventral view of the tergum, both show the postphragma (*Pph*) depending from the posterior edge of the pseudonotum, though it is often restricted to the middle of the latter.

The pseudonotum always carries the postphragma. Verhoeff regards it as a development of the postphragma, but it is probably a better statement of the facts to say that the phragma is a development of the pseudonotum, for in the lower insects the latter is a large flat plate, while the phragma may be simply a thin fold projecting downward from its posterior edge. In the mesothorax of Lepidoptera, Hymenoptera, and Diptera this condition, however, is reversed, the phragma being developed to a great size, although the pseudonotum itself is not reduced. The postphragma is really a

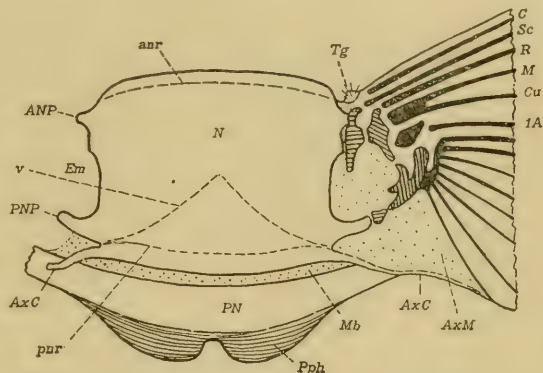


FIG. 1.—DIAGRAMMATIC TERGUM OF ANY COMPLETE WING-BEARING SEGMENT, AND THE BASE OF THE WING, DORSAL VIEW; 1A, FIRST ANAL VEIN; ANP, ANTERIOR NOTAL WING PROCESS; anr, LINE OF ANTERIOR VENTRAL NOTAL RIDGE (ANR OF FIG. 2); AxC, AXILLARY CORD; AxM, AXILLARY MEMBRANE; Cu, COSTA; Cu, CUBITUS; Em, LATERAL EMARGINATION OF NOTUM; M, MEDIA; Mb, MEMBRANE BETWEEN NOTUM AND PSEUDONOTUM; N, NOTUM; PN, PSEUDONOTUM OR POSTNOTUM; PNP, POSTERIOR NOTAL WING PROCESS; pnr, LINE OF POSTERIOR VENTRAL NOTAL RIDGE (PNR OF FIG. 2); Pph, POSTPHRAGMA; R, RADIUS; Sc, SUBCOSTA; Tg, TEGULA; v, LINE OF MEDIAN OR V-SHAPED VENTRAL NOTAL RIDGE (V OF FIG. 2).

chitinization of the infolded intersegmental membrane behind the pseudonotum, for it is always composed of two closely appressed or fused laminae. The first is directly continuous with the pseudonotum, the second is connected with the notum of the segment following, generally by membrane but sometimes directly, as when the segments are fused.

The pseudonotum is conspicuous in the metathorax of Coleoptera (132-140, *PV*). It is the plate that Straus-Dürckheim (1828) named the "tergum" in *Melolontha vulgaris* (135, *PV*), but most authors have followed Andouin (1824) and Newport (1839) in calling it the "post-scutellum." This name is appropriate when a scutum

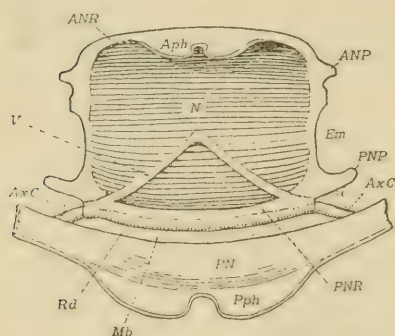


FIG. 2.—DIAGRAMMATIC TERGUM OF ANY COLEOPTERAN WING-BEARING SEGMENT, VENTRAL VIEW; ANP, ANTERIOR NOTAL WING PROCESS; ANR, ANTERIOR NOTAL RIDGE; Aph, PREPHRAGMA; AxC, AXILARY CORD; Em, LATERAL EMARGINATION OF THE NOTUM; Mb, MEMBRANE BETWEEN NOTUM AND PSEUDONOTUM; N, NOTUM; PN, PSEUDONOTUM; PNP, POSTERIOR NOTAL WING PROCESS; PNR, POSTERIOR NOTAL RIDGE; Pph, POSTPHRAGMA; Rd, POSTERIOR REDUPLICATION OF THE NOTUM; V, V-SHAPED VENTRAL RIDGE OF NOTUM, THE ENTODORSUM.

and scutellum can be distinguished. Berlese (1906) recognizes and figures the plate in the Coleoptera, but he refers it to the abdomen, calling it the "acrotergite" of the first abdominal segment. Such a disposition of the sclerite, however, is clearly impossible on account of its intimate connection, an articulation (*i*) in beetles, with the epimera of the metathorax. In the mesothorax of Coleoptera there is no pseudonotum unless the two small plates (127, 128, 131, *q*) yoking the mesonotum to metanotum are rudiments of it. The pupæ of beetles do not show a pseudonotum even in the metathorax. In *Dendroctonus valens* (122, 126), and in *Tetropium velutinum* (123) it is easy to see

that no pupal plate intervenes between the metathoracic notum or wing-bearing sclerite (*N<sub>3</sub>*) and the first abdominal tergum (*IT*). The latter can be identified by the first abdominal spiracles.

In the Plecoptera the pseudonotum is a large, simple plate in both the meso- (75) and the metatergum. It is partly overlapped by the notum (*N*). In a nymphal tergum, however, there is no trace of it (76), and its site is entirely membranous (*Mb*). It is similar in Neuropteran adults (142), but lacking in the pupa (141).

In the Lepidoptera (149), the Hymenoptera (169), and the Diptera (174 and 179) the pseudonotum is present in both segments and is easily distinguishable as the tergal plate behind the wing bases. In the mesothorax of these orders it carries the large phragma (150,

163, 170, 179, *Pph* or *Pph*<sub>2</sub>) that projects posteriorly through the metathorax and almost shuts off the cavity of the thorax from that of the abdomen. In a Tipulid pupa (173) the mesopseudonotum (*PV*) is present as a large plate intervening between the two wing-bearing plates (*N*<sub>2</sub> and *N*<sub>3</sub>). It is interesting to note here that the halter is a wing-like structure (*W*<sub>2</sub>).

The pseudonotum has been discussed at considerable length because the fact has apparently not been recognized by other authors that the postscutellum or pseudonotum is an independent plate in its origin and is, hence, not one of the divisions of the notum, as is the prescutum, scutum, or scutellum.

The notum (*N*) or wing-bearing plate of a meso- or metathoracic tergum is diagrammatically illustrated in figs. 1, 2, and 3. In its simplest form it is an undivided plate, convex dorsally. On its ventral surface (fig. 2) the anterior and posterior margins are thickened, forming the anterior notal ridge (*ANR*) and the posterior notal ridge (*PNR*). The latter is generally folded forward a short distance on the ventral surface, forming a free posterior reduplication (*Rd*) which often overlaps the sclerite following. The lateral margins of the notum are produced into two processes which carry two of the articular sclerites of the wing base. These lobes are the *anterior notal wing process* (*ANP*) and the *posterior notal wing process* (*PNP*). The posterior edge of the notum, formed by the posterior reduplication, usually appears as a marginal thickening which is continued outward on each side as a corrugated, cord-like thickening of the anal edge of the basal membrane of the wing. These thickenings may appropriately be called the *axillary cords* (*AxC*). They are important characters in determining the posterior limit of the notum. The anterior notal ridge bears the *anterior phragma* or *prephragma* (*Aph*).

This outline might be taken to represent the structure of the meso- or metatergum of primitive winged insects, for it is approximately that of nymphal and some pupal forms though these lack the notal wing processes. A pseudonotum is never present in nymphal stages and the prephragma is usually but little developed. The tergum of the nymph is illustrated in the Odonata (15), in the Mantidæ (31), in the Acridiidae (56, 58) and in the Perlidae (76). The same simplicity is exhibited by the pupal tergum of Coleoptera (122, 123, 126). In a Tipulid pupa (173), however, the pseudonotum is present in the mesothorax as a distinct plate (*PV*<sub>2</sub>) between the two wing-bearing plates (*N*<sub>2</sub> and *N*<sub>3</sub>). As will be shown later, the notum of the adult is commonly divided more or less distinctly into several regions or even sclerites. But a study of nymphs and pupæ shows conclusively that these notal divisions are secondary characters in the growth of the individual. The tergum consists at



first of one plate—the notum, from the entire lateral margins of which the wings develop. Behind the notum is added, in the adult stage, the pseudonotum (postscutellum) as a distinct plate, while the so-called prescutum, scutum, and scutellum are formed as secondary divisions of the notum. These notal regions, moreover, are not homologous in all the orders. This can be proved by a study of the ventral surface of the notum, which presents certain fundamental characters common to nearly all insects. Two of these are the anterior and posterior notal ridges (fig. 2, *ANR*, *PNR*) already described; a third, and the most important one, is the V-shaped ridge (*V*), the *entodorsum* of Amans (1885), located on the posterior half of the notum, having its apex forward and the bases of its arms fused with the posterior ridge. A comparison of text figs. 1 and 2 will show that the three ventral ridges (*ANR*, *V*, *PNR*) form three transverse lines on the surface of the notum (*anr*, *v*, *pnr*).

These ridges and their surface lines are undoubtedly homologous structures in all insects. They mark off the area of the notum into four regions, as follows: (1) A narrow anterior marginal band in front of the line of the anterior ridge; (2) a large bilobed region situated between the line of the anterior ridge (*anr*) and that of the entodorsum (*v*) and carrying the notal wing processes (*ANP*, *PNP*); (3) a triangular space between the line of the entodorsum and that of the posterior notal ridge; and (4) a narrow posterior marginal band terminating laterally in the axillary cords (*AcC*) and forming the posterior free edge or reduplication of the notum.

This typical simplicity of structure is illustrated in the Orthoptera by *Blattella* (38, 40) and *Gryllus* (49, 50), and in the Neuroptera by *Corydalus* (142, 143). It will be observed that the pseudonotum (*PN*) is absent in the Orthoptera, but well developed in *Corydalus*.

These four regions of the Orthopteran notum are very suggestive of the four divisions of the tergum as ordinarily recognized, but a comparison with *Corydalus* (142) at once shows that the term "postscutellum" can not be applied to any part of the Orthopteran tergum, for the name belongs to the pseudonotum, which is absent in Orthoptera. Hence, all identifications of a "postscutellum" in Orthoptera, supposed to be homologous with that of the higher orders, are erroneous. A comparative study of the orders shows that the posterior line (*pnr*) is generally absent, that the notum is very commonly divided by lines or actual sutures into three subdivisions, and that these lines or sutures are *not* determined by the ventral ridges and do not bear the same relation to them in the different orders.

Thus we have the following premises: (1) The ventral ridges of the notum are constant in all the orders and are, hence, fundamental homologous structures; (2) three notal divisions are of general



occurrence but are not constant nor do they present the same relation to the ventral ridges in the different orders. From these facts it follows that the notal divisions are not necessarily homologous wherever they occur, though they may be so within limited series, and that they are simply secondary adaptations to some common demand upon the notum.

The above statements and conclusion can be verified by a study of the species illustrated on the plates. Since the subdivisions of the notum are best developed in the highest orders these will be described first. The ordinary names of *prescutum* (*pse*), *scutum* (*set*), and *scutellum* (*scl*) will be used to designate the notal regions, but the reader must bear in mind that they are not used in the different orders in a homologous sense, and that the abbreviations on the figures do not designate parts necessarily homologous. The "postscutellum" will be called the pseudonotum (*PV*).

The notal divisions are probably as well shown in the mesothorax of a Tipulid fly as in any other insect. In *Holorusia grandis* (174, 175) the prescutum (*pse*) is a large plate with its posterior margin produced posteriorly in a large V-shaped angle, having no relation to the anterior notal ridge. The lateral posterior angles are produced into two small lobes (175, *u*) lying opposite the anterior angles of the wing bases. The scutum (*set*) is a wide plate carrying the anterior notal wing processes (*ANP*). The scutellum (*scl*) consists of a median elevated shield and of a depressed area on each side. The posterior wing processes belong to the latter, though they are separated from it by a tongue of membrane. The ventral V ridge is present just as in the diagram (fig. 2), but it marks only the apex (*v*) of the scutellum, its lateral parts not showing on the surface. Thus the three divisions of the Tipulid notum are but slightly influenced by the ventral ridges. The pseudonotum (*PV*) is well developed, consisting of a median and two lateral plates, the latter articulated with the epimera (174, *Epm*). In a Tabanid (179, 180) the third division of the notum (*scl*) is distinct but the first (*pse*) and the second (*set*) are not separated mesially. The lateral angles (*u*) of the prescutum, as in *Holorusia*, lie opposite the wing bases.

In the Hymenoptera similar divisions of the notum occur, as is well shown in the drawing (160) of *Parasiobla*, a Tenthredinid. An examination of the ventral surface reveals the V ridge present but situated entirely behind the suture between the scutum and scutellum. These two plates, furthermore, are easily separable along this suture and, hence, the latter can in no way be compared with the dividing line between the scutum and scutellum of the Orthoptera. In the example given (160) the prescutum (*pse*) is perfectly exposed, but it is more commonly hidden in the Hymenopteran mesothorax by the pronotum (169, *N<sub>1</sub>*), which is attached to and overlaps

the anterior part of the mesothorax. The pseudonotum (*PV*) is also usually hidden on account of its projecting downward before the metathorax. It can easily be shown, however, by removing the mesotergum from the surrounding parts (163, 170).

The metanotum in both the Diptera and Hymenoptera is reduced in size and the subdivisions are not well marked (174, 169). The metapseudonotum is present in both orders but is generally very narrow in the Diptera. In the Hymenoptera it is usually a large plate (160, 169, *PV*<sub>3</sub>) continuously fused on the sides with the metaepimera (*Epm*<sub>3</sub>), though in some cases it is narrow and scarcely distinguishable from the metanotum (164).

In the Hymenoptera there occurs a fusion of the first abdominal segment with the metathorax. This fact has led to a great deal of discussion among entomologists and to the production of an immense amount of literature. Latreille (1821) first described the rear part of the apparent Hymenopteran thorax as being a part of the abdomen and named it the "segment médiaire." Newman later (1833) called it the "propodeon." Packard (1866), by a study of the development of *Bombus*, proved that the first abdominal segment is actually transferred to and becomes consolidated with the metathorax. A great many other writers have written a great many opinions about it and about the opinions of other writers, and Gosh (1881) has furnished a voluminous historical account of all the opinions of all these writers up to his time. To his Contribution to the History of Entomology (1881) the reader is referred if he is interested in this phase of the subject. If not, the examination of a few specimens of the insects concerned will probably suffice.

The abdomen of *Cimbea* (166) shows clearly enough that the first abdominal segment (164, *IT*) is much more closely attached to the thorax than to the rest of the abdomen. That the part in question is the first abdominal segment is proved by its spiracles (*ISp*) and by the structure of the metathorax and of the rest of the abdomen. The metathorax of *Cimbea* (164) has, in addition to the attached part (*IT*), its full complement of sclerites. The notum (*N*) and pseudonotum (*PV*) are present dorsally and the episternum (*Eps*) and the epimerum (*Epm*) laterally. In the abdomen itself, if the first segment behind the one in question is counted as the first, there would be present only nine segments in all, and the absurdity would be forced upon us of referring the female gonapophyses to the seventh and eighth segments. Hence, arguing from either end, the conclusion would be that the *median segment* belongs to the abdomen. In *Parasiobla* (160) this segment could never be regarded as more than a slightly transposed part of the abdomen. However, in the higher forms, of which *Pepsis* (169) is a good representative, the median segment is so intimately grown into the metathorax that it certainly does not

appear to belong to the abdomen. Yet in the metathorax there is present the true metathoracic notum ( $N_m$ ), and the pseudonotum ( $PV_m$ ) identifiable by its fusion with the metathoracic pleura. Hence the large corrugated plate ( $IT$ ) behind the pseudonotum has no place in the metathoracic anatomy, and its abdominal origin is proved by its spiracles ( $ISp$ ). Thus a study of comparative anatomy proves conclusively that the "segment médiaire" is at least the first abdominal tergum which has been transferred to the thorax, and *Pepsis* indicates that the entire first abdominal segment is so transferred. If this is true, then the ventral part disappears as a distinct plate in the higher families.

In the Lepidoptera the mesonotum has much the same appearance as in the Diptera and Hymenoptera, but differs in details of structure. In the Cossidae (149, 150) it consists of a large scutum ( $set$ ) and scutellum ( $scel$ ) separated along the line of the ventral V-ridge, and of a very narrow prescutum (150,  $pse$ ). The postscutellum ( $PV$ ) is present, but normally (149) is almost hidden between the mesothorax and the metathorax. In the Sphingidae (155, 156) the prescutum depends vertically from the anterior edge of the scutum (155) and carries the prephragma ( $Aph$ ). The prescutum in *Phassus* is, therefore, much more nearly the equivalent of the anterior division of the notum in the diagram (fig. 1) than in either the Hymenoptera or the Diptera and, hence, is more similar to the Orthoptera (38) and Neuroptera (142). In the Diptera, it will be recalled, the prescutum is large and extends back to the bases of the wings. In the Hymenoptera it is remote from the wing bases. In *Phassus* (150) the scutum carries both the anterior and the posterior-wing processes of the notum, while in *Protoparce* (156) the posterior processes arise from the scutellum. This is due to the fact that here the lateral parts of the scutellum are not defined by the ventral V-ridge, but appear simply as depressed areas at the sides of the median elevated part of the scutellum as in *Holorusia* (175) and *Tabanus* (180). In this case the separation between the scutum and scutellum laterally is simply a matter of topography.

The metathorax of *Phassus* (149, 151) is larger and more like the mesothorax than is usual among the higher insects. The prescutum ( $pse$ ) and the scutellum ( $scel$ ) almost meet on the median line, thus separating the scutum into two lateral plates ( $set$ ). The posterior wing processes ( $PVP$ ) arise in the angles between the scutellum and the scutum.

The scutellum in all the forms so far described carries the axillary cords of the wings ( $AxC$ ) at its extremities. These cords, which are distinct in nearly all insects, are, hence, diagnostic of the location of the scutellum in Lepidoptera, Hymenoptera, and Diptera, defining its posterior margin, and consequently, the posterior edge of the



notum. The postscutellum (*PV*) lying behind them is always a plate more or less distinctly separated from the notum, but connected or continuously fused with the epimera.

In the Coleoptera there occur two special modifications of the metathoracic tergum which set the beetles apart in this respect from all the other orders. One of these characters is the forward extension of a median tongue of the scutellum toward the prescutum, cutting the scutum into separated lateral halves. The second character is the division of each lateral scutal plate again into two by lines formed by special transverse ventral ridges laterad of the apex of the V-ridge.

In a separate paper (1909) the author has shown that Audouin's interpretation of the coleopteran tergum is untenable, that, in order to make out his four transverse tergal sclerites, Audouin has represented certain parts as continuous which in nature are separate, and in other cases has made separations where none occur.

A Carabid, *Calosoma scrutator* (132, 133), presents a very simple arrangement of the metatergal subdivisions characteristic of the beetles. The prescutum (*pse*) consists of a large quadrate median part and of two narrow lateral arms widened terminally into the triangular anterior notal wing processes (*ANP*). The median part is separated by a membranous area (*mb*), the "toile" of Straus-Dürckheim (1828), from the anterior extension of the scutellum on the floor of the median notal groove (*G*). On its anterior ventral edge the prescutum carries the prephragma (*Aphe*) mesially and the cup-shaped muscle apodemes (*MD*) laterally. The scutum (*set*, *set*) is divided into four plates by the median approximation of the prescutum and scutellum, and by the lines (132, *w*) formed by the special transverse ventral ridges (133, *w*). The posterior division on each side carries the posterior notal wing process (*PNP*). The scutellum (132, *scl*) presents a median enlargement carrying the tongue extending forward on the floor of the median notal groove (*G*) and determined by the entodorsum or ventral V-shaped ridge (133, *V*), while laterally it extends to the bases of the axillary cords (*AxU*) as a narrow marginal postscutal strip on each side, determined by the posterior notal ridge (*PNR*).

Behind the notum, and entirely separated from it by a flexible suture, is the pseudonotum (postscutellum) (*PV*), carrying the postphragma (*Pph*) and articulating at its extremities (*i*) with the epimera.

*Dytiscus dauricus* (136, 137), is very similar in its metatergal structure to *Calosoma* (132, 133). The lateral arms of the scutellum, however, are larger and, in addition to carrying the axillary cords, they support the combined bases (*v*) of the anal veins of the wing. The ventral ridges (137, *V*, *w*) are much larger than in *Calosoma*.



The higher families of beetles, illustrated by *Hydrophilus triangularis* (134), *Melolontha vulgaris* (135, 138), and *Cyllene robinia* (140), have a prescutum somewhat different in appearance from that of *Calosoma* and *Dytiscus*. In *Hydrophilus* (134) and *Cyllene* (140) its median part (*pse*) is narrow and arched forward, and the membranous area (*mb*) back of it is extended transversely. The scutellum (*sc*) appears to have a long median tongue (*G*) by itself entirely separating the scutum into lateral halves. The anterior scutal subdivisions, in front of the transverse dividing lines (*w*), which are incomplete in *Hydrophilus*, are reduced to turgid antero-lateral corner lobes. The lateral extensions of the scutellum in each of these genera fuse laterally with the parts in front of them, so that the axillary cords (*AxC*) appear to be attached to the margins of the scutum (134, 140). *Melolontha vulgaris* departs still more widely from the *Calosoma-Dytiscus* type. The median part of the prescutum is represented entirely by the very large prephragma (135, 138, *Aph*), which is supported by the lateral parts of the prescutum and separated from the scutum and scutellum by an extensive membranous area (*mb*). The scutum (135, *set*, *set*) is divided, as in the other genera, into lateral halves by a median tongue of the scutellum (*sc*) on the floor of the median notal groove (*G*), but the transverse ridges (138 *w*) are coincident with the anterior scutal margins and do not subdivide the scutal plates. The scutellum (*sc*) is not defined laterally, but two triangular postero-lateral divisions of the scutum, the "scapulaire posterieure" of Straus-Durekheim (1828) carry the posterior notal processes (*PNP*) and the axillary cords.

The pseudonotum is well developed in all of these genera (134, 135, 140, *PN*) and carries the postphragma (*Pph*). The latter is specially large and of complicated structure in *Melolontha* (139, *Pph*).

The mesonotum of beetles is apparently constructed on the same plan as the metanotum. A pseudonotum is lacking. In *Calosoma* (127) and *Dytiscus* (128) the prominent shield-shaped area (*sc*) corresponds with the median part of the scutellum of the metanotum, lateral arms extending from it which carry the axillary cords (*AxC*). Laterad of the median shield are the separated halves of the scutum (*set*) carrying the posterior wing processes of the notum (*PVP*). In front of it is a large complex prescutal part (*pse*) carrying the anterior phragma (*Aph*) and laterally the anterior notal wing processes (*ANP*). Two little plates (*q*) lie between the mesonotum and the metanotum. These may be rudiments of a mesopseudonotum, but they are more closely connected with the metanotum than with the mesonotum. On the ventral surface of the mesonotum (131) a V-shaped ridge (*V*) is present similar to that of the metanotum. In most other beetles the parts of the mesonotum are so blended that any plan of structure closely corresponding with that of the metanotum

can not be made out. Yet a progressive modification from the *Calosoma-Dytiscus* type can be traced through *Hydrophilus* (125), *Cyllene* (129), and *Dendroctonus* (124).

It is thus clear that the same fundamental structure of the notum obtains throughout the Coleoptera, the Lepidoptera, the Hymenoptera, and the Diptera, but that the notal subdivisions are not necessarily determined by it.

In the Neuroptera a tergum of diagrammatic simplicity is found. In *Corydalus* (142, 143) the scutum (*scd*) and scutellum (*scel*) are separated along the line (142 *v*) of the ventral V ridge (143 *V*). Anteriorly and posteriorly are narrow marginal areas defined by the anterior and posterior notal ridges (*ANR*, *PNR*). The first of these might be called the prescutum, but the second is simply the posterior notal reduplication (*Rd*) and does not correspond with the postscutellum of higher orders, for this is the pseudonotum, which is well developed in *Corydalus* (142, *PN*).

In the Euplexoptera the metanotum of *Spongiphora* (96) consists of an undivided plate carrying both the anterior and the posterior wing process (*ANP*, *PNP*), while articulated near the middle of its posterior margin are two long arms (*f*) bearing the axillary cords (*AcC*). In the mesonotum (90) there is a large anterior triangular part carrying the anterior notal wing processes (*ANP*) and two lateral divisions carrying the posterior wing processes (*PNP*). It is evident, however, that neither tergum of *Spongiphora* is normal, for neither presents any trace of the V-shaped ridge, and the general shape is peculiar to the order. A ventral view of the mesonotum (92) shows that the two apparent divisions are due merely to elevations and depressions of the surface.

In the Belostomidae of the Hemiptera the mesonotum presents a wide, strongly declivous prescutal area carrying the prephragma and limited posteriorly by a definite transverse line. Back of it are two transverse grooves separating three other divisions. The last is simply the long posterior reduplication which in the Hemiptera overlaps the mesonotum. There is but a faint trace of the V ridge in *Benacus* and it does not influence the notal subdivision. The metanotum is also much modified, carrying an unusually large prephragma and lacking the V ridge. In *Benacus* (87) it is clear that both of the notal wing processes (*ANP* and *PNP*) arise from the scutum. A very narrow pseudonotum (88 *PN*) is present, connecting with the epimera laterally. The first abdominal tergum (*IT*) is also much modified and closely connected with the pseudonotum. It can be identified by its lateral spiracles (*I Sp.*).

In the Plecoptera, as illustrated by *Pteronarcys californica* (75), the indistinct regions of the notum are due entirely to the topography. The anterior and posterior notal regions are weakly developed while

there are but indistinct traces of the V ridge. The apex of the latter is entirely lacking, so that the area corresponding with the median part of the scutellum of the Diptera or Lepidoptera here appears as a median posterior lobe of the scutal region. This is very suggestive of the Acridiidae. The pseudonotum (PN) is a large plate equally developed in both meso- and metathorax of adults, though conspicuously absent in the nymphs.

The simple type of tergum occurring in the Orthoptera has already been described and is illustrated by *Blatella* (38, 40) and by *Gryllus* (49, 50). Both of these forms present a meso- and metanotum of almost typical diagrammatic form. The pseudonotum is lacking in all Orthoptera (see p. 558), and the divisions of the notum are only such as are indicated by the ventral ridges. All other regional diversifications are purely topographical.

In a winged Locustid, *Microcentrum laurifolium*, neither the mesonotum (39) nor the metanotum (41) shows any subdivisions except such as are marked out by elevations and depressions. Only rudiments of the V ridge occur (V). A small-winged adult Locustid, such as *Anabrus simplex*, has the notum (42) of almost nymphal simplicity.

In the Acridiidae the meso- and metanotum are almost identical with each other. An under view of the mesonotum of *Hippiscus phonicopterus* (54) shows considerable departure from the other Orthopteran families. The V-shaped ridge (V) is low and flat and not ridge-like. The posterior notal ridge (PVR) is, however, well developed and is almost phragma-like. Diverging forward and outward from its middle are two high thin ridges (*s, s*) which do not occur in the other families. The posterior reduplication (Rd) forms a marginal thickening carrying laterally the axillary cords (AxC). On the dorsal surface (53) five regions are distinguishable. The first is a narrow median anterior area separated by a suture-like line (*aur*) formed by the anterior notal ridge. The second occupies most of the back and consists of two large anterior lateral lobes and of a smaller median posterior lobe. It bears the anterior notal wing processes (ANP). The third and fourth divisions lie laterad of the median posterior lobe and are demarked by the lines of the posterior notal ridge (*pur*) and the ridges (*s, s*) diverging from the latter. Each is a transverse, elongate oval area tapering mesially, laterally bearing the posterior wing process (PVP). The fifth region, marked in front by the line of the posterior notal ridge (*pur*), is the thickened posterior reduplication carrying the axillary cords (AxC).

This description, as far as the writer can see, expresses the facts concerning the Acridiid mesonotum. Yet, various entomologists, by a vigorous exercise of the imagination, have made out four transverse divisions, thus compelling the locust to fall in line with the beetles,



moths, and flies. It may be very gratifying to imagine that it does, but, when it clearly does not, what is gained by imagining that it is as it is not?

The pronotum of nearly all the Orthoptera is a simple plate, but when we come to the Acridiidae we find it divided into four very distinct transverse parts. In fact the pronotum of *Melanoplus* affords the most popular illustration of the quadruple construction of the insect back. But here (51) it must be observed that the notum not only covers the dorsum, but has usurped the territory of the pleurites (*Eps*, *Epm*) which it has all but crowded out. An examination of the inner surface (52) shows that the third external groove (*z*) marks an internal ridge against which the inner lamina of the long posterior reduplication (*Rdl*) ends. The middle groove (*y*) marks a large internal notal ridge (*NR*) exactly similar to the internal pleural ridge (*PR*) of any normal thoracic pleurum such as that of the mesothorax of *Anabrus* (44) or of *Dissosteira* (71). There is present even a notal apodemal arm (*NA*) representative of the normal pleural arm (*PA*). The coxa is carried by an apparently notal coxal process (*NCxP*) in every way similar to the ordinary pleural coxal process (*CxP*), though this may really belong to the rudimentary pleurum. Finally, the leg muscles are disposed upon the notal surfaces at each side of the middle notal ridge just as they are upon the episternum and epimerum of a normal pleurum. Hence, it is clear that we have here simply a secondary modification of the notum due to its assumption of the duties of the pleural plates which it has crowded out. It is really most illogical that the pronotum of *Melanoplus* should be offered as a typical example of a thoracic tergum, for a tergum doing duty as both notum and pleura is, on the face of it, not typical. Yet in almost any discussion of insect anatomy the prescutum, scutum, scutellum, and postscutellum will be found principally illustrated by the pronotum of an Acridiid.

In the Odonata the pronotum of both nymphal and adult forms is divided into three transverse lobes by two transverse grooves. They are best developed in adults (5, 7, 9, 13), but are well marked also in the nymphs (8, 12). An unusual feature in some is the extension downward from the third lobe of a postepimeral strip (*a*) of the notum. The meso- and metanotum are sufficiently shown by the illustration of *Pachydiplax longipennis* (17). The two are similar and each is subdivided somewhat as in the Acridiidae and the Perlidae. The wing articulation shows few of the characters common to all the other orders except the Ephemera, and the wing muscles are nearly all attached to the base of the wing itself, a condition peculiar to the order. The pseudonotum (*PV*) is well developed in each segment. In the mesothorax (*PV<sub>2</sub>*) it is exceptionally large and is divided by ventral ridges into a median and two lateral lobes.



The Ephemerid mesotergum and metatergum are sufficiently shown in the drawings of *Hexagenia bilineata* (4, 3). Each presents simply a confusion of elevations and depressions showing little similarity to any other order. A posterior median lobe, however, suggests the similarly situated lobe in Odonata (17), Acridiidae (53), and Perlidae (75), and also the median part of the scutellum of Lepidoptera (150), of Hymenoptera (161), and of Diptera (175). It is also comparable with the median shield-shaped area of the mesothorax of Coleoptera (127, 128). A pseudonotum (3, *PV*) is present in each segment, but is hidden from above by a posterior membranous fold margined by the axillary cords (4, *Aæ C*).

This review of the notal structure in the different orders will show that the diagrammatic conception of the notum illustrated in fig. 2 is really the fundamental notal structure that prevails in all the principal orders except the Ephemerida and the Odonata. It is evident that the three ventral ridges—the anterior, the V-shaped, and the posterior—are constant characters and that the regions they mark off can be regarded as homologous in all the orders. But such subdivisions are not the ones usually apparent on the surface, and the latter, though generally the same within an order, vary so much in different orders that they can not be regarded as homologous structures except within limited series.

Three factors contribute to the formation of the notal subdivisions as follows: (1) Topography, as elevations and depressions of the surface forming more or less distinct regions, some of which appear variously modified throughout nearly the entire insect series; (2) ventral ridges, three of which are constant characters and, hence, to be regarded as homologous in the different orders; and (3) depressed suture-like lines and actual sutures, variable and not the same in different orders and, hence, not necessarily defining homologous sclerites.

Therefore, it may be concluded from a study of development and comparative anatomy that any scheme of thoracic structure in insects is untenable which postulates four primitive transverse plates in the tergum. Much less is there any evidence that the definitive tergum is composed of the united terga of two or four primitive metameres.

This conclusion is opposed to that of Berlese (1906), who finds in the thoracic terga of all orders four exactly corresponding parts, the "acrotergite," the "protergite," the "mesotergite," and the "metatergite." An examination of his colored diagrams (1906, Plate 4) will show, however, that in order to carry out his scheme Berlese has in many cases drawn purely arbitrary lines across the notum. Moreover, he has disposed of the pseudonotum by making it the "acrotergite" of the segment following the one to which it is attached. Thus he equates the mesopseudonotum and its phragma in *Sphinx* with the metaprephragma of *Acridium*. The pseudonotum

(postscutellum) of *Hydrophilus* he evidently calls the acrotergite of the first abdominal segment and equates it with the anterior subdivision of the first abdominal tergum of *Acridium*. He appears to disregard entirely the intimate connections

of the pseudonotum with the epimeral plates belonging to the segment of the preceding notum and its attachment to the preceding notum itself.

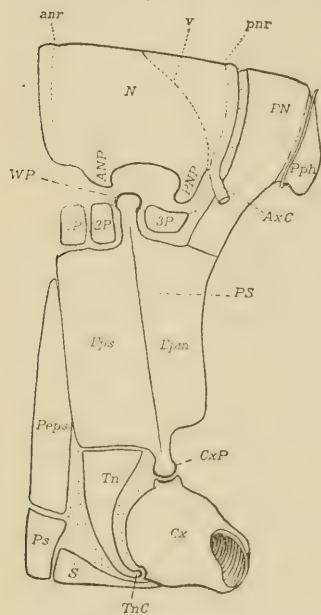


FIG. 3.—DIAGRAMMATIC LATERAL VIEW OF ANY COMPLETE WING-BEARING SEGMENT, EXTERNAL; ANP, ANTERIOR NOTAL WING PROCESS; anr, LINE OF ANTERIOR VENTRAL NOTAL RIDGE; AxC, AXILLARY CORD; Cx, COXA; CxP, COXAL PROCESS OF PLEURUM; Epm, EPIMERUM; Eps, EPISTERNUM; N, NOTUM; 1P, 2P, EPISTERNAL PARAPTERA OR PREPARAPTERA; 3P, EPIMERAL PARAPTERUM OR POSTPARAPTERUM; PN, PSEUDONOTUM OR POSTNOTUM; PNP, POSTERIOR NOTAL WING PROCESS; pnr, LINE OF POSTERIOR VENTRAL NOTAL RIDGE; Pph, POSTPHRAGMA; PS, PLEURAL SUTURE; Ps, PRESTERNUM; S, STERNUM; Tn, TROCHANTIN; TnC, TROCHANTINAL COXAL CONDYLE; v, LINE OF VENTRAL V-SHAPED NOTAL RIDGE; WP, PLEURAL WING PROCESS.

## 2. THE PLEURUM AND COXA.

The key to the structure of the pleurum is the *pleural suture*. To determine this proceed as follows: Find the pleural process that supports the base of the wing; locate the pleural condyle to which the coxa is articulated; observe the impressed line that extends between these two articular knobs. This is the pleural suture. The *episternum* lies in front of it, the *epimerum* behind it. In wingless forms the pleural suture must be determined by the coxal articulation alone. The suture may be horizontal, in which case the contiguous plates necessarily lie above and below it. Very rarely it is lacking, though such is conspicuously the case in the metathorax of most of the Hymenoptera. Internally the pleural suture forms a large ridge along its entire length, and this *pleural ridge* is of great assistance in determining the pleural suture when the latter is obscure or when there are other similar sutures externally.

The plan of any wing-bearing thoracic pleurum is illustrated diagrammatically by figs. 3 and 4. Externally (fig. 3) is seen the *pleural suture* (PS) extending upward to an arm bearing the wing, the *pleural wing process* (WP) and ventrally to a condyle bearing the coxa, the *pleural coxal process* (CxP). Internally (fig. 4) is seen the heavy *pleural ridge* or *entopleurum* (PR), a large ridge-like apodeme lying along the line of the pleural suture, terminating in

the wing process (*WP*) above and the coxal process (*CxP*) below, and bearing a *pleural arm* (*PA*) projecting inward and downward.

Anterior and posterior to the pleural suture, or ventral and dorsal to it when the suture is horizontal, are the episternum (*Eps*) and the epimerum (*Epm*), respectively. These are the two principal plates of the pleurum, and, by their contiguous and infolded edges, they form the pleural suture externally and the pleural ridge internally. The epimerum is nearly always connected, either by an articulation or by fusion, with the lateral part of the pseudonotum (text fig. 3, *PN*).

A study of nymphal pleura (*Melanoplus*, 55, 56) shows clearly that the episternum and epimerum are merely subdivisions of one original plate to which the leg is articulated. Before the wings are developed, the pleural suture does not extend to the dorsal edge of the plate. On the inner surface (55) the pleural ridge (*PR*) is well developed ventrally to strengthen the plate in its function as a supporter of the leg, and the pleural suture is merely the external mark of the formation of the ridge. All the upper pleural structures, the wing process, and the parapteral plates are developed only when the wing becomes functional. In forms with rudimentary wings in the adult stage, such as *Anabrus simplex* (43, 44), these parts are present, but reduced in size. A study of the Chilopoda also appears to indicate that the episternum and epimerum originate as subdivisions of one plate. The lower chilopods, such as *Mecistocephalus* (20), present a number of plates on the side of the segment, one of which (*Pl*) lies immediately over the coxa. The series running through *Scolopocryptops* (21), *Lithobius* (22), and *Cermatia* (23) shows a disappearance of all the other plates, while this one in *Cermatia* (23, *Pl*) becomes divided by a median thickening into two parts resembling the episternum and epimerum of a nymphal orthopteran (56).

Associated with the base of the wing are several small plates lying before and behind the wing process (*WP*). These are the paraptera (*P*). There are never more than two in front of the wing process and they may be called the *episternal paraptera* or the *preparaptera* (1 *P*, 2 *P*). There is generally only one *epimeral parapterum* or *postparapterum* (3 *P*), though some Perlidæ present a second. Voss

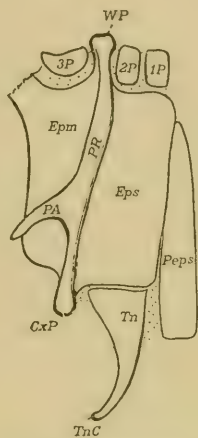


FIG. 4.—DIAGRAMMATIC VIEW OF INNER SURFACE OF THE PLEURUM OF ANY COMPLETE WING-BEARING SEGMENT; *CxP*, COXAL PROCESS OF PLEURUM; *Epm*, EPIMERUM; *Eps*, EPISTERNUM; 1 *P*, 2 *P*, EPISTERNAL PARAPTERA OR PREPARAPTERA; 3 *P*, EPIMERAL PARAPTERUM OR POSTPARAPTERUM; *PA*, PLEURAL ARM; *Peps*, PRE-EPISTERNUM; *PR*, PLEURAL RIDGE (ENTOPLEURUM); *Tn*, TROCHANTIN; *TnC*, TROCHANTINAL COXAL CONDYLE; *WP*, WING PROCESS OF PLEURUM.



(1905) calls the preparaptera the "episternalgelenkplatten," and the postparaptera the "epimeralgelenkplatten." These are excellent descriptive terms but too cumbersome for translation into English or Latin equivalents, and it is well to preserve the name "parapterum" of Audouin.

Either one or both of the episternal paraptera are connected with the head of the costal vein of the wing by strong membrane, and upon their inner surfaces are inserted the strong pronator wing muscles by whose contraction the wing is turned forward upon the pleural wing process and its costal or front edge depressed. In the higher insects there is frequently only one preparapterum present and it very commonly carries a large muscle disc on its inner surface which forms the insertion of the pronator muscle. This whole structure is called the "appareil de pronation" by Amans (1885). The muscle disc may be specifically designated as the *pronator disc* (*PD*). This is not shown in the diagram, for it occurs mostly in the higher orders. As examples of it see illustrations of the Euplexopteran metathorax (98, 100, *PD*), the Coleopteran mesothorax (101, 129), the Coleopteran metathorax (110-121), and the Hymenopteran mesothorax (165). In the Lepidoptera (154) the pronator disc (*PD*) is carried by the upper edge of the episternum, but the parapterum (*P*) is also fused with the latter.

In the Coleoptera there is only one preparapterum present. In the mesothorax it is usually represented by a small inconspicuous plate or rod connected with the head of the elytrum and lying before the wing process (102, 103, 105, 107, 108, *P*), only in rare cases does it bear a pronator disc (101, 129, *PD*). In the metathorax, on the other hand, the disc is always large and prominent (110-121, *PD*). In *Calosoma scrutator* (Carabidae) the parapterum and its disc (110, 113, *P* and *PD*) are loosely articulated to the front of the wing process (*WP*). In *Dytiscus dauricus* (Dytiscidae) the parapterum (114, 115, *P*) is closely articulated to the front of the wing process. In *Hydrophilus triangularis* (Hydrophilidae) the parapterum (*P*) is fused with the base of the wing process (111, 112) and to the anterior edge of a subdivision (*eps*) of the episternum (*Eps*). The line of fusion, however, is easily seen. The same condition is found in *Melolontha vulgaris* (Scarabaeidae) where the base of the parapterum (121, *P*) and the episternal subdivision (*eps*) are closely united. Finally, in such forms as *Cyllene robiniae* (Cerambycidae) and *Dendroctonus valens* (Scolytidae) these two parts (116, 118, *P* and *eps*) are so entirely fused that the line of union is gone. Thus in the higher beetles the appearance of two wing processes (118, *P* and *WP*), carried by the episternum and epimerum, respectively, is produced. The series of forms just described, however, shows conclusively that this condition is secondarily brought about through



the fusion of the base of the parapterum with the front of the episternum. The same thing occurs less conspicuously in several other orders. In the Neuroptera, *Corydalus cornuta* (147) has the single preparapterum (*P*) fused with the upper end of the episternum (*Eps*), thus giving the appearance of there being two wing processes. The same thing is true of the Trichoptera as shown by *Neuronia ocellifera* (146, 148). Even in the Lepidoptera the parapterum (*P*) of *Phassus triangularis* (153) is not really separated from the episternum (*Eps*), and forms a large lobe in front of the wing process (*WP*). Here the base of the wing process sends a long arm (153, 154, *tgA*) forward and upward to support the tegular plate of the notum (150 *tg*). This, however, is peculiar to the Lepidoptera. It will be observed that in all cases the true wing process can be identified by the fact that it is derived from both the episternum and the epimerum, while the process formed of the parapterum is connected only with the episternum.

The postparapterum or epimeral parapterum (text figs. 3, 4, *β P*) is of less importance than the preparaptera. It is a small plate of irregular and variable shape lying in the membrane of the base of the wing behind the wing process of the pleurum. It is often lacking, being never present in beetles. It is illustrated in the Corrodentia (82, *β P*), the Trichoptera (146, 148, *β P*), the Lepidoptera (149, 153, 154, *β P*), and the Diptera (174, 176, 179, *β P*).

In a few of the lower orders a plate frequently occurs before the episternum (text figs. 3, 4, *Peps*). This is the sclerite which Verhoeff (1903) calls the "katopleure" in the Euplexoptera (Dermaptera) and it is well shown in this order by *Spongiphora* (94, *Peps*). But the plate which Verhoeff so designates in the Blattidæ (32, 35, *eps*) would seem to be only a subdivision of the episternum (*Eps*) not comparable with the sclerite in Euplexoptera. The writer formerly (1908) adopted the name "katopleure" for this sclerite, but here substitutes the more appropriate term *preepisternum* suggested by Dr. A. D. Hopkins. The *preepisternum* falls in line with the presternal element (*Ps*) of the ventral parts (text fig. 3, *Peps* and *Ps*).

The *preepisternum* is illustrated in the prothorax (26, *Peps*) and the mesothorax (27, 28) of *Spodromantis guttata* (Mantidæ), in the mesothorax (35) of *Ischnoptera hyalina* (Blattidæ), in the mesothorax (43, 44) of *Anabrus simplex* (Locustidæ), in the mesothorax (47) of *Gryllus pennsylvanicus* (Gryllidæ), in the nymphal meso- and metathorax (55, 56) of *Melanoplus*, in the adult (57) of *Hippiscus phanicopterus*, and the adult (70, 71) of *Dissosteira carolina* (Acrididæ), and finally in the mesothorax (94) of *Spongiphora apicidentata* (Forficulidæ). It does not appear to be present in the higher orders, though anterior subdivisions of the episternum occur, especially in the mesothorax of Coleoptera (102, 107, 109). Such

subdivisions, however, are never detached plates, but are simply parts of the episterna equivalent to the superior subdivisions (102, 105, 109, *cpm*) of the mesothoracic epimera (*Epm*), and to the subdivisions (111-121, *cpm*) of the metathoracic epimera. The writer formerly (1908) wrongly identified this last plate with the postparapтерum, a sclerite which is absent in the Coleoptera.

An important sclerite in the pleurum of insects and undoubtedly a primitive plate in the thorax is the *trochantin* (*Tn*). This is a plate lying in front of the coxa (text fig. 3, *Tn*), connected above with the lower edge of the episternum (*Eps*) and articulating below by a small condyle (*TnC*) with the ventral rim of the coxa. Hence, when the trochantin is present, the coxa turns on a hinge line between the coxal condyle of the pluerum (*CxP*) and the coxal condyle of the trochantin (*TnC*). The trochantin is well shown in the Mantidae (26, 27, 28) and in the Blattidae (29, 32, 35). In the latter family it is divided into two parts (*Tn* and *tn*). The smaller part (*tn*) is what Comstock and Kochi (1902) call the "second antecoxal piece," but this part carries the coxal articulation and is, therefore, certainly the principal part of the trochantin.

The trochantin is well developed in the Locustidae (43) and the Gryllidae (46, 47). It is small or rudimentary in the Acridiidae (51, 56). In the Plecoptera its upper end is fused with the episternum in the meso- and metathorax (78, 79). In the prothorax it inserts itself entirely between the episternum and epimerum and the coxa (72, 73, *Tn*), thus separating the latter from its true pleural coxal process. By way of reparation to the coxa, however, the trochantin develops a dorsal coxal condyle (72, 73, 74, *Tn CxP*) in addition to its usual ventral coxal condyle (*TnC*). It even goes further and actually presents an internal trochantinal ridge (74, *TnR*) simulating the true pleural ridge (74, *PR*). This is, of course, a highly specialized condition.

The trochantin occurs in typical form in the Euplexoptera (91, 94, 98, 100). It is present in the prothorax of *Benacus* (Hemiptera) though concealed by the overlapping pleurum (83 *Tn*). In most of the Coleoptera it is a very small plate in the pro- and mesothorax (99, 104, *Tn*) concealed at the upper end of the coxa within the coxal cavity. In the Silphidae (106) and Buprestidae (109), however, it is an exposed plate (*Tn*) occupying the normal position between the episternum (*Eps*) and the coxa (*Cx*). It is absent in the Coleopteran metathorax. In the Neuroptera (147) and Trichoptera (146, 148) it is a large plate. In the Lepidoptera (149, 153, 154, 158, 159) it is partially or entirely fused with the episternum, and is not very distinct from an arm of the sternum (*S*) in front of it. Its ventral coxal articulation is weak or absent. In the Hymenoptera and Diptera the trochantin is either absent or is indistinguishably consolidated with the sternum.

If there is any close relation between the plates of a chilopod segment and those of an insect thoracic segment a study of the former would indicate that the trochantin is really a sternal element. In *Mecistocephalus* (20) the lower half of the coxa is surrounded by a large bilobed lateral subdivision (*Tu*) of the sternum (*S*). In *Scolopocryptops* (21) this plate (*Tu*) is atrophied behind the coxa but articulates with the latter by a special condyle. *Lithobius* (22) shows a similar condition, but here the lower end of the trochantin-like plate (*Tu*) is overlapped by what is the median division of the sternum in *Mecistocephalus*. Verhoeff (1903) calls this plate in the Chilopoda the "trochantin." It is absent in *Cermatia* (23). Börner (1903) regards the trochantin as a "sternales schnürstück" and not as a pleural plate.

Audouin (1824) first specifically applied the term "trochantin" to the plate in *Buprestis gigas* which intervenes between the "epimerum" and the coxa. It happens, however, that in *Buprestis* the episternum presents a number of subdivisions, and Audouin must have included the posterior of these with the epimerum, thus referring to the trochantin as articulating the "epimerum" with the coxa. (See *Buprestis arulenta*, 109, *Tu*.) It will be evident, however, that the plate called "trochantin" by Audouin in *Buprestis* is the plate which in this paper is identified as such in all the orders where it occurs.

Verhoeff (1903) designates as the trochantin the sclerite lying before the coxa and carrying its ventral articulation.

Comstock and Kochi (1902), as already stated, define as the "trochantin," in the Blattidae, a plate which is only a part of the entire trochantin, since it does not carry the ventral coxal articulation. The subdivision of the trochantin bearing the latter is the "second antecoxal piece" of Comstock and Kochi.

Comstock and Kellogg (1902) describe the trochantin as a plate "considered to be an appendage of the coxa between the coxa and the antecoxal piece."

Packard (1896) defines the trochantin as a posterior division of the coxa attached to the epimerum. He refers to the "coxa meron" of Walton (1900) in the Neuroptera, Trichoptera, and Lepidoptera, which is not the trochantin at all, but a subdivision of the epimerum fused with the hind edge of the coxa.

The writer agrees with Verhoeff (1903) in his conception of the trochantin, because this appears to agree with Audouin's original use of the term.

Sometimes small additional plates occur between the trochantin and the coxa. These may be called *accessory trochantinal* or *accessory coxal sclerites*, according as they are associated more with the trochantin or the coxa (91, 94, 98, 100, *Tna*, *Cxa*).



The coxa (*Cx*) is too familiar to need any special description. As already shown (text fig. 3) it is articulated dorsally to the coxal process of the pleurum (*CxP*) and ventrally to the coxal process of the trochantin (*TnC*). The latter may be a sternal element, but it is only in the nymphs of Odonata that the coxa is articulated directly to the sternum (11, 16, *d*). In the Hemiptera and the Coleoptera the upper ends of the coxæ are usually hidden by the overlapping pleurites, but even in such cases the coxa will usually be found articulated to a hidden coxal process of the pleural ridge.

The coxa has often been conceived of as a double structure representing elements corresponding with the episternum and the epimerum. The basis for this idea is furnished chiefly by the Neuroptera, Trichoptera, and Lepidoptera. Here the meso- and metathoracic coxæ of adults are composed distinctly of an anterior and a posterior segment (147, 148, 149, 153, *Cx* and *cpm*). Banks (1893) regarded the coxa as derived from two segments, the leg being the appendage of the first in each pair and the coxal spur of *Machilis* representing the appendage of the second segment. Walton (1900) described the two coxal segments as the "coxa genuina" and the "coxa meron." Packard (1898) called the posterior division the "trochantin."

A study of larval and pupal forms in the Neuroptera and Trichoptera shows that this double structure of the coxa is a purely secondary condition. In the larva of *Corydalus cornuta* (144) the meso- and metacoxæ are simple structures like the prothoracic coxa. The epimerum is divided by an oblique groove into an upper plate (*Epm*) and a lower plate (*cpm*). In the pupa (145) the lower epimeral subdivision (*cpm*) has extended downward behind the coxa (*Cx*) and is partially joined to it. In the adult (147) the lower epimeral plate (*cpm*) is entirely fused upon the rear side of the coxa (*Cx*) and, moreover, is separated by a membranous area from the upper epimeral plate (*Epm*). This would appear effectively to dispose of the bisegmental notion of the structure of the coxa in this order. The same developmental process can be shown to take place in the Trichoptera. A pupa of *Neuronia ocellifera* (146) has a long extension (*cpm*) of the epimerum (*Epm*) united to the posterior edge of the coxa (*Cx*). In the adult (148) this is separated from the upper part of the epimerum and appears as a posterior segment (*cpm*) of the coxa (*Cx*). Probably the same condition could be shown in a freshly pupated Lepidopteran.

Hence, it may be concluded that the double structure of the coxa in these orders is purely a secondary modification and can in no way be used as evidence of a bisegmental origin of the thoracic segments.

### 3. THE STERNUM.

The writer has not been able to make an extensive study of the sternum. Comstock and Kochi (1902) have recognized three trans-



verse divisions of the chitinous ventral parts and designated them the *presternum*, *sternum*, and *sternellum*. These three parts are shown in the mesothorax of a cockroach (32, *Ps*, *S*, and *Sl*). The presternum, however, is more commonly present as two small plates lying near the anterior angles of the sternum, the "Vorplatten" of German entomologists. Such plates are present in the prothorax of the Odonata, in a few species of which they unite across the median line in front of the sternum (11, *Ps*), but more usually form two lateral plates separated from the median presternal part (6, 7, 10, *Ps*). In most cases they are, furthermore, fused with the episterna (11, 12, 13, *Ps* and *Eps*). The presternal plates are shown also in the Locustidae (43), the Gryllidae (46, 47), the Perlidae (80), the Corrodentia (82), and in the Forficulidae (91, 94, 98).

From the inner sternal surface there projects dorsally the *entosternum*, consisting most commonly of two chitinous arms, the *furca* (text fig. 6, *Fc*). In some cases the base of the entosternum appears to mark the line between the sternum and sternellum. It is shown to be an invagination by the pit or pair of pits which often marks its location externally (10, 11, *c*). Sometimes the sternum bears also a long median posterior apodemal arm. This is shown in the prothorax of a moth (152, *l*).

#### V. THE WING ARTICULATION.

The wings are articulated to the body by a simple arrangement of axillary sclerites, two of which hinge upon the anterior and posterior wing processes of the notum while one rests upon the wing process of the pleurum. This is true of all the orders except the Ephemera and the Odonata. These will, therefore, be omitted from the present discussion and described later under the special descriptions of the orders.

Text figs. 1 and 5 sufficiently represent the *axillary sclerites* (1 *Ax*, 2 *Ax*, 3 *Ax*, 4 *Ax*) in their relations to one another, to the notal wing processes, and to the bases of the veins, while fig. 6 shows the articulation with the pleurum. The fourth axillary is usually absent, but since it occurs in the Orthoptera and the Hymenoptera and since, when it is present, the arrangement is more symmetrical, it is included in the diagrams. When it is absent the third axillary articulates directly with the posterior notal wing process. Several other less definite plates usually occur in the central part of the wing base associated with the median, cubital, and first anal veins. These plates, however, are too variable to be given distinctive names and will be referred to in general as the *median plates*.

The membrane of the wing base may be named the *axillary membrane* (*AxM*). On its anterior margin opposite the base of the costal vein is a small, hairy, semichitinous pad (*Tg*). This, in

the higher insects, develops into a scale-like lobe overlapping the base of the wing. In such cases it is known as the *tegula*, but this name is used in the present paper to designate both the well-developed tegula of the Lepidoptera, Hymenoptera, and Diptera, and its pad-

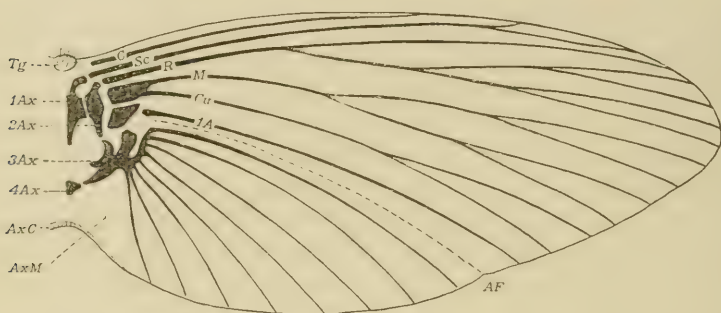


FIG. 5.—DIAGRAM OF A GENERALIZED WING AND ITS ARTICULAR SCLERITES OR AXILLARIES: 1 A, FIRST ANAL VEIN; AF, FIRST ANAL FOLD; 1 Ax, 2 Ax, 3 Ax, 4 Ax, FIRST, SECOND, THIRD, AND FOURTH AXILLARIES; AxC, AXILLARY CORD; AxM, AXILLARY MEMBRANE; C, COSTA; Cu, CUBITUS; M, MEDIA; R, RADIUS; Sc, SUBCOSTA; Tg, TEGULA.

like representative in other orders. The posterior free margin of the axillary membrane is thickened in such a way that it has the appearance of being a corrugated cord attached to the posterior angle of the notum. It is here called the *axillary cord* (AxC).

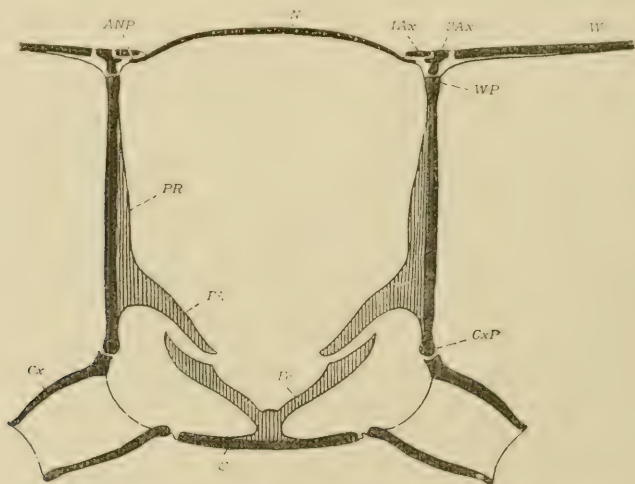


FIG. 6.—DIAGRAMMATIC CROSS SECTION OF A WING-BEARING SEGMENT; ANP, ANTERIOR NOTAL WING PROCESS; 1 Ax, FIRST AXILLARY; 2 Ax, SECOND AXILLARY; Cx, COXA; CxP, COXAL PROCESS OF PLEURUM; FC, FURCA (ENTOSTERNUM); N, NOTUM; P.A, PLEURAL ARM; PR, PLEURAL RIDGE (ENTOPLEURUM); S, STERNUM; W, WING; WP, WING PROCESS OF PLEURUM.

Occasionally some of the four principal axillaries are subdivided and sometimes there occur small extra chitinizations in the axillary membrane. Thus confusion has arisen through different authors

having based schemes of general nomenclature upon some one form which happens to possess a prominent individual peculiarity.

Jurine (1820) first described in *Xylocopa violacea* the sclerites of the wing base and gave them individual names. The first he called the *grand humeral* in the front wing and the *scutellaire* in the hind wing; the second the *petit humeral* in the front wing and the *diademal* in the hind; the third the *petit cubital* in the front wing and the *furche* in the hind; the fourth the *naviculaire* which occurs in the fore wing only of *Xylocopa*.

In the same year Chabrier (1820) described the axillary sclerites of *Melolontha vulgaris* and named the three principal ones the *humerus*, the *omoplate*, and the *onguiculaire*, respectively.

The axillaries were next described by Straus-Dürckheim (1828) in *Melolontha vulgaris*. He called them collectively the *epaulieres* in the elytrum and the *axillaires* in the hind wing, while he designated the individual sclerites numerically according to their order in each case. In the wing base of *Melolontha* there are four sclerites, but one of these is an accessory plate not represented in other forms, while the fourth of Orthoptera and Hymenoptera is not present. Hence the individual designations of anterior, second, third, and fourth axillaries used by Straus-Dürckheim can not be consistently applied in the various orders, the third in the *Melolontha* series being an extra piece.

Amans (1885) made a comparative study of the wing articulation in all the insect orders. He recognized three proximal articular sclerites which he named individually the *sigmoide*, the *median*, and the *terminal*, while he designated as *retro-median* the distal median plate or plates. He accurately described all of them and their relations to surrounding parts. Little can be added to his account.

Lowne (1892) in studying the blowfly called the first axillary the *dens*, the second the *unguiculus*, and two parts of the third the *metapterygium* and *deltoid*.

Voss (1905) in describing the external anatomy of *Gryllus domesticus* has given the best detailed account of any one species. Unfortunately, however, the cricket does not afford a typical example of the subject. Although Voss includes in his excellent paper a review of the wing articulation in all the orders, yet he bases his scheme and system of nomenclature on *Gryllus*, in some species of which the first axillary sclerite is divided into two. This same condition occurs also in some of the Locustidæ, but, as far as the writer has observed, is confined to the Locustidæ and the Gryllidæ, and is not constant in either of these families. It certainly can not be regarded as typical. However, the fourth primary axillary is present in *Gryllus*, and Voss's nomenclature is as follows: The two parts of the first axillary and the fourth, which articulate the wing to the back, are named



the anterior, middle, and posterior tergal plates (*Tergalplatten*), respectively; the second, articulating with the pleural wing process, is the middle hinge plate (*Mittlegelenkplatte*); while the third is named the posterior anal hinge plate (*Analgelenkplatte*).

Berlese (1906) in treating of the wing articulation, as in his treatment of the thorax, attempts to line up the parts in four consecutive series corresponding with the division of the tergum. In order to make his scheme consistent, he calls the hairy pad representing the tegula, on the front edge of the wing base, the *acroptero*. The first and second axillaries, though figured as perfectly distinct, are included under the name *proptero*, the third is the *mesoptero*, while the name *metaptero* is given to a rare sclerite in the axillary membrane which does not correspond with the fourth sclerite of Orthoptera and Hymenoptera. The latter Berlese identifies in *Aceridium* as the "mesoptero," although a sclerite is present in *Aceridium* which in every way corresponds with his "mesoptero" of other orders.

The writer retains in the present paper the general term of *axillaries* used by Straus-Dürckheim, and designates the individual sclerites as the *first*, *second*, *third*, and *fourth*, though, as already pointed out, this enumeration does not correspond with that of Straus-Dürckheim. (For synonymy see Glossary.)

It will not be necessary to describe in detail the axillary parts in each order. They can be sufficiently made out by a study of plates 47, 48, 64-69, and a comparison with text figs. 1 and 5 will show the general plan which prevails. The four principal axillaries are indicated by the numerals 1, 2, 3, and 4; by the abbreviations 1 *Ax*, 2 *Ax*, 3 *Ax*, and 4 *Ax*; or by shading in transverse lines for the first and fourth, in oblique lines for the second, and in longitudinal lines for the third. The median plates are indicated by broken oblique lines. The articulation of the sclerites to the notum is shown in figs. 75, 90, 96, 127, 128, 129, 131, 136, 150, and 161, and by text figs. 1 and 6.

The wing base is a difficult subject to illustrate because the small sclerites are so easily turned in slightly different positions and then present very different appearances. Most of the drawings have been made by getting first a camera lucida sketch of the specimen mounted in water or glycerine and flattened out under a cover glass, and then drawing in the details from dissections and a closer examination under a binocular microscope. But perhaps a dozen different drawings could be made from the same specimen all differing in details. The following are general descriptions of the specific characters of the various elements of the wing base.

*The tegula (Ty).*—This is usually a membranous or semichitinous pad-like lobe developed on the anterior membranous part of the wing root near the base of the costal vein. It is nearly always made con-



spicuous by the long hairs upon it. (As typical examples see 60-63, 185, 186, 188, 200, *Ty*). In the Diptera, Hymenoptera, and Lepidoptera the tegula is highly developed in the mesothorax as a large scale-like lobe overlapping the base of the wing. (Diptera, 210, 212; Hymenoptera, 205, 206; Lepidoptera, 149, 150, 202). In the Lepidoptera the tegula is so large that it is supported by a special plate of the mesonotum (150, 156, *tg*), which in turn is supported by a large tegular arm (153, 154, *tg.1*) from the base of the pleural wing process (*WP*).

The tegulae of the Lepidoptera must not be confounded with the *patagia* which occur in some families of this order. The *patagia* are large thin lobes developed on the pronotum and are specially well developed in such genera as *Agrotis* and *Geometra*. They are simply thin expansions of the pronotum. In *Agrotis* they may be seen in an intermediate condition.

Lowne (1892) uses the term "epaulet" for the tegula of the blow-fly. He says that it does not correspond with the tegula of the Hymenoptera. They certainly have identical situations on the wing base, however, and it is hard to see how they could be independent organs. Lowne's objection is based on the relative position of the anterior spiracle, but the spiracle belongs to the pleurum and its position in the two orders is different on account of the different modifications of the pleurites. It is the spiracle that is shifted and not the tegula.

*The first axillary (1, 1 Ax, transverse shading).*—This sclerite is supported by the anterior notal wing process (*ANP*) and can readily be determined by this connection. It consists of a flattened body articulating externally with the second axillary, and of a curved anterior neck which abuts against the head of the costal vein (*C*). In some cases the neck is absent and then the first axillary is separated from the costa. Sometimes, as in a few Orthoptera, the neck is detached from the body and appears as an independent sclerite.

*The second axillary (2, 2 Ax, oblique unbroken shading).*—This is the pivotal sclerite of the wing base, that is, the one by means of which the wing rests and turns upon the wing process of the pleurum (text fig. 6). The articulation is generally by means of a large ventral process of the axillary which fits against an articular surface on the posterior side of the wing process. The dorsal surface of this sclerite articulates by a long ridge with the outer edge of the first. Its anterior end is usually associated with the head of the radial vein of the wing (*R*), being either fused with it or contiguous to it (text figs. 1, 5). There is generally a large muscle disk attached by a ligament either directly to the posterior end of the second axillary (199, *MD*) or to the axillary membrane near it. In an exceptional case (*Cyllene* 140) it is attached to a special process of the notum (*o*). The ven-

tral end of the muscle inserted upon this disk is attached to the anterior edge of the metacoxa in beetles. This is probably the principal muscle concerned in bending the wing toward the body.

*The third axillary* (3, 3, *Ax*, *longitudinal shading*).—This sclerite serves principally as a means of folding the anal region of the wing. When the fourth is absent it articulates directly to the posterior notal wing process. It nearly always presents a scoop-like muscle process on the side next the body at right angles to its long axis. The muscle inserted upon this turns the third axillary on its axis and thus causes a folding of the anal region of the wing. In the beetles this muscle is attached by a ligament first to a smaller accessory sclerite. The outer edge of the third axillary is always connected with the bases of the anal veins; frequently the latter are fused with it by a common flexible chitinous base.

*The fourth axillary* (4, 4*Ax*, *transverse shading*).—When this small sclerite is present it forms the posterior hinge plate of the wing, intervening between the posterior notal wing process (*PVP*) and the third axillary.

*The median plates* (*oblique shading in broken lines*).—These lie between the base of the radius (*R*) and the third axillary. They are variously developed but are principally associated with the bases of the media, the cubitus, and the first anal when the latter is separated from the other anals. Often one of them is fused with the third axillary and sometimes none of them is present.

*The axillary membrane* (*AxM*).—This is specially developed along the anal margin of the wing base where it is bordered by the axillary cord. It nearly always forms an ample expansion here, but in the wings of flies and the elytra of beetles it forms large folded lobes. These are called the *squamæ* or *alulae* in the Diptera (212, *Al*). The similar membranous lobes under the elytra of some beetles (131, *Al*) are certainly the same things as the alulae of Diptera. Comstock and Needham (1898) have already suggested this and cited the marginal cord-like structures (131, *AxC*) arising from the posterior angles of the scutellum as evidence.

*Axillary cord* (*AxC*).—This is the corrugated cord-like thickening along the posterior margin of the axillary membrane. The pair, one on each side, originate from the posterior lateral angles of the notum, and are thus valuable marks in determining the limits of this plate when the latter is obscured by close connection with the parts following.

*The wing veins* (*C*, *Sc*, *R*, *M*, *Cu*, *A*).—Most of these are connected or associated in a very definite and constant manner with the sclerites of the wing base. The latter are certainly a valuable asset in the identification of the veins in the different orders. Comstock and Needham (1898, 1899), however, have left little to be said on this

subject, and a study of the axillaries simply confirms the results of these authors derived from a study of the venation itself.

The general relation of the veins to the axillaries is shown in text figs. 1 and 5. The *costa* (*C*) does not connect with any of them. Its base very generally forms a separate piece from the main costal shaft, and is connected by strong membrane with the preparaptera of the pleurum. This separated costal head will be seen clearly by a review of Plates 64-69.

The head of the *subcosta* (*Sc*) articulates with the anterior end of the neck of the first axillary, except in rare cases of special modification. (For typical examples see 184, 187, 201, 206.) The base of the *radius* (*R*) is nearly always more or less closely fused with the base of the *subcosta* (*Sc*), but it is clearly connected also in a great many cases with the anterior end of the second axillary (182-184, 185, 186, 192, 198, 203, 204, 208). In other examples its head is only contiguous to the third axillary (185, 188, 191, 202, 209, 210, 211, 212). In a few beetles the radius and second axillary are separated by a wide membranous space (193, 194).

The *media* (*M*) and the *cubitus* (*Cu*) are closely associated with each other at their bases and with the median plates. A simple arrangement is shown in the wings of *Corydalis cornuta* (200, 201). But both the media and the cubitus are so frequently fused with the radius that their basal parts are difficult to determine in a definite manner (186, 187, 202, 203, 205, 206, 207). In other cases they are perfectly distinct at their bases (192, 194, 195, 198, 200).

The *first anal vein* (1.1) is separated from the rest of the anals in the Orthoptera by the *anal fold* (see figures on Plates 47, 48). The only apparent exception to this noted by the writer is in the front wing of *Gryllus* (67). In the wing of a nymphal mantid (59) the first anal (1.1) clearly arises at the base of the wing, independent from the rest of the anals. Comstock and Needham (1898, '99) have shown the same thing in a drawing of the wing of a cockroach nymph. The other anals generally arise from a common base, which is connected or fused with the third axillary. The *vena dividens* (60, *D*) is not a primary anal, but a secondary vein developed in the first anal fold (62, 64, 66, 117). In most other orders the anals are fewer, and the first is not specially separated from the rest.

The peculiar structure of the base of the wing in dragonflies will be described under the Odonata in Section VII.

## VI. GENERAL CONCLUSIONS.

1. The fourth head segment, apparent in some of the lowest insects, is still regarded as a doubtful metamere by some embryologists. Assuming its genuineness, the following general statement seems pretty well established: The head of insects is composed of six con-



solidated primary segments, with the appendages of the following or neck segment attached to it forming the labium, and sometimes also with the sternum of this segment intimately fused into its ventral surface forming a gular sclerite.

2. The microthorax is formed from the embryonic segment immediately following the last of the consolidated head metameres. It is the segment of the neck of the adult. Its sclerites form the cervical sclerites of the neck, often reduced or rudimentary, and the gular plate of the head when such a plate is present. Its appendages always fuse with each other, and become closely associated with, generally attached to, the base of the head, and constitute the labium.

3. The thorax proper consists of three segments, or of three with the tergum of the first abdominal segment added in the Hymenoptera. These three segments are primary metameres, and there is no real evidence of each having been formed through a fusion of two or more primitive segments. The original thoracic region may have consisted of more than three segments, but if so, the extra segments have disappeared and have taken no part in the formation of the thoracic sclerites in modern insects.

4. The thoracic sclerites in all insects conform to one definite plan represented diagrammatically in fig. 3. The sclerites are subdivisions of the wall of one primitive segment, and the apparent double nature of each segment is secondary. Characters that have been urged as special evidence to the contrary, such as the equivalence of the episternum and epimerum and the double structure of the coxa in some orders, lose their significance when nymphal, larval, and pupal forms are examined. The episternum and the epimerum are subdivisions of one original plate on the side of the segment, and the posterior segment of the coxa shown by some orders is simply a detached piece of the epimerum fused upon the coxa in the adult stage.

5. The primitive tergum is a single undivided plate from the entire lateral margins of which the wings arise. This simple tergal structure is shown by the nymphs of all the lower insects and by many larvæ and pupæ and by the adults of Orthoptera. In the adults of all the other principal orders, however, there is present behind this wing-bearing plate or true notum a second tergal plate, the postnotum or pseudonotum, developed in the intersegmental membrane of the nymph or pupa, having no connection with the wings, but attached to the upper ends of the epimera.

The notum presents three fundamental ridges on its ventral surface as shown in text fig. 2. Its subdivisions do not, in most cases, closely conform with these ridges, nor do they strictly correspond in all the orders. They are in general similar but not necessarily homologous.



6. The pleurum consists fundamentally of a plate strengthened internally by a heavy, inflected, median, vertical ridge to support the wing above and to carry the leg below. Thus it has become divided into the episternum anteriorly and the epimerum posteriorly, separated externally by the pleural suture along the line of the internal pleural ridge. (See text figs. 3 and 4.) The wing support forms a wing process and the coxal support the coxal process of the pleurum. In front of the episternum there is in some of the lower insects a pre-episternum. Along the base of the wing parapteral plates are developed. In front of the coxa is the trochantin, a plate possibly derived from the sternum, articulating above with the episternum and below forming the ventral articulation of the coxa.

7. The wing is hinged to the notum on the two notal wing processes, and is supported from below upon the wing process of the pleurum.

In the Ephemera and Odonata the chitinous wing base is directly continuous with the walls of the thorax. In all other orders there is an articulation formed by several axillary sclerites in the membranous base of the wing. Three of these are of definite characteristic shape and of constant recurrence in all the orders and are present in the elytra of beetles and the halteres of flies. In the Orthoptera and Hymenoptera a fourth sclerite occurs, and this number may be regarded as the full complement. When four are present the first and fourth articulate with the anterior and posterior notal wing processes, respectively, the second articulates with the wing process of the pleurum, while the third supports the anal veins and is concerned in the plication of the anal region when the latter is folded. Where the fourth is absent the third articulates with the posterior notal process.

## VII. SPECIAL CHARACTERS OF THE ORDERS.

### A. CHILOPODA.

A study of the Chilopoda in connection with a study of the insect thorax brings out the following two interesting features:

1. A serial examination of the pleurum of *Mecistocephalus* (20), *Scelopocryptops* (21), *Lithobius* (22), and *Cermatia* (23) appears to indicate that only one plate (*Pl*) of the numerous pleurites on each segment in the lower Chilopoda (20) persists in the higher (23), and this plate is suggestive of being the one from which the episternum and epimerum of the Hexapoda are formed. Compare *Cermatia* (23, *Pl*) with the *Melanoplus* nymph (56, *Eps* and *Epm*).

2. The trochantin (*Tn*) appears to be originally a lateral subdivision of the sternum (20). The part behind the coxa disappears (21, 22) while the part in front extends upward to the pleurites. In *Cermatia* (23), however, it is gone entirely.

These points are simply suggestive and it is not claimed that a close relation necessarily exists between the Chilopoda and the Hexapoda. Verhoeff (1903), however, goes further than this and identifies both the episternum (coxopleure) and epimerum (anopleure) with separate plates of the chilopod pleurum.

## B. HEXAPODA.

### I. APTERA.

Since the importance of this order is philosophical rather than practical, the author has not devoted much time to its study. Moreover the external anatomy of the thorax in the three principal genera has been thoroughly exploited by Verhoeff (1903, 1904a).

As is well known, the Japygidae possess a small intercalary tergal plate between the pronotum and the mesonotum and another between the latter and the metanotum. By many authors these are regarded as rudiments of primitive segments and the primitive thorax is conceived to have been composed of three pairs of segments described and named by Verhoeff (1903c, 1904a) as follows: The microthorax and prothorax, the stenothorax and mesothorax, and the cryptothorax and metathorax. But this subject has been discussed in Section II, dealing with the segmentation of the head and body (p. 519).

Verhoeff (1903) describes the pleura of all three segments of *Japyx* as very similar to the pleurum of *Lithobius*. He shows in *L. forficatus*, however, two plates above the one attached to the coxa (22, Pl) instead of one as shown by the species figured in this paper (22). The microthorax is represented by a sternal plate only. In *Lepisma*, according to Verhoeff, the prothoracic pleura have all the parts of the pleura of Blattidae and Euplexoptera (Dermaptera), but the parts are rudimentary in the mesothorax and the metathorax. The microthorax in this genus, also, consists of a large sternum but has no pleural or tergal plates. In *Machilis* the three segments differ much from those of either *Japyx* or *Lepisma*. The microthoracic sclerites and the pleurites of the other three segments are almost lacking, while the terga are largely developed and reach far down on the sides of the thorax.

In *Japyx* each thoracic segment bears a spiracle, while a fourth spiracle is present close to the lateral margin of the mesosternum and near its posterior edge. Hence, this spiracle must be the spiracle of a degenerate segment.

Verhoeff (1903) regards the Thysanura not as insect "progenitori," but as a degenerate residuary branch of the primitive wingless insects. This view is undoubtedly the correct one.

## II. EPIHEMERIDA.

*Species studied.*—*Hexagenia bilineata* (1, 2, 3, 4).

*Characteristics.*—Shows little similarity to other orders of insects, except to Odonata, which are suggested by structure of wing articulation. Notum and pseudonotum present in mesotergum and metatergum. Lateral parts of mesonotum (4) complicated by irregular confusion of elevations and depressions. Axillary cords (*Ax C*) arising from middle of posterior edge of notum, pseudonotum hidden from above. On mesopleurum (1) wing process (*WP*) and pleural suture (*PS*) present, but episternum and epimerum are regions not definitely defined as plates. Epimeral region continuous with pseudonotum (*PV*). Wing veins flexible at base, merging into edges of tergum. Only one axillary sclerite developed (4, *1Ax*). Metatergum smaller than the preceding (3), both notum and pseudonotum present. Metapleurum with distinct wing process (*WP*), but without definitely formed pleurites or pleural suture.

## III. ODONTA.

*Species studied.*—*Libellula auripennis* (5, 6, 18, 19), *L. pulchella* (16), *Pachydiplax longipennis* (7, 10, 15, 17), Libellulidae: *Lestes uncatus* (8, 9), *Enallagma durum*, Agrionidae: *Gomphus brevis* (11, 13), *G. pagiatus* (12, 14), Aeschnidae.

*Characteristics.*—1. Microthorax represented in both nymphs and adults by a number of plates on sides of the neck (5, 6, 8, 9, 12, *mi*, 1 *mi*, 2 *mi*, 3 *mi*, 4 *mi*) closely associated with side of the prothorax and forming a long arm on each side of neck reaching forward into concavity of the back of head.

2. Pronotum topographically divided into three distinct transverse lobes (5, 7, 8, 9, 12, 13, *N*), the third often with a descending postepimeral strip (5, 7, 12, *a*).

3. Prothoracic pleurum shows an evolution from such simple forms as shown by nymph of *Lestes uncatus* (8) and adult of *Pachydiplax longipennis* (7) to forms such as *Gomphus pagiatus* (12) and *Gomphus brevis* (13) where epimerum (*Epm*) forms principal plate on side, episternum being divided into a small upper piece (*eps*) fusing with epimerum (12), and into a larger ventral plate (*Eps*) fused with lateral plate of presternum (*Ps*).

4. Presternum (*Ps*) of the prothorax varies from a transverse plate with expanded lateral part (11), to a condition where it consists of two plates independent of the sternum and lying at sides of the latter (5, 6, 7, 9, 10). These plates in some forms, as shown under 3, completely fuse with lower subdivision of episternum (11, 12, 13).

5. Prosternum connected with the mesosternum by two slender rods (6, 7, 10, 11, 18, *b*).

6. Prothoracic spiracle plates closely associated with mesothorax in the nymph (14, 16, *Sp*). In the adult they unite with each other across the back, thus forming a complete spiracular dorsum (18, *g*) which fuses with mesothorax in front of declivous part of the latter formed by dorsal parts of episterna.

7. Trochantin lacking in both nymphs and adults.

8. Coxæ of all the segments in the nymphs articulate ventrally with the sternum by a special condyle (11, 16, *d*).

9. Episterna of mesothorax and metathorax subdivided in both adults (18, 19) and nymphs (14, 16) into an upper plate (*cps*) and a lower plate (*Eps*). In mesothorax the upper meets its fellow of opposite side along the mid dorsal line between the true mesonotum and the prothoracic spiracular bridge (18 *g*). An old nymph (14) shows an intermediate condition of this modification. In metathorax the upper plate of episternum (*cps*) fused with preceding epimerum (*Epm*). Hence, the two oblique sutures on side of combined meso- and metapleura are the two pleural sutures (16, 18, *PS*), while the incomplete middle one is the remnant of the intersegmental suture. In metathorax the epimera (18 *Epm*) meet each other along the mid ventral line behind metasternum, just as do episterna of mesothorax in front of mesotergum.

10. Pleural wing process (18, 19) divided into two arms, the posterior of which is the true wing process (*WP*) articulating with wing, while the anterior (*h*) is an arm supporting the large costal lobe of humeral angle of the wing.

11. The flexible bases of wing veins (17) merge into edges of notum as in Ephemèrida. Only one distinct axillary is present (17, *Ax*). Base of the costa (17, 181, *C*) forms a large tripartite lobe at humeral angle of wing supported on anterior arm (*h*) of wing process (18, 19). Median point of wing base, formed principally by base of radius, articulates, by a ventral process, with true pleural wing process (18, 19, *WP*). This process thus corresponds with second axillary of other orders.

Lendenfeld (1881) has made an exhaustive study of the details of the thoracic structure and the wing articulation in Odonata. If the reader is interested in minutiae and in cumbrous Latin names he is referred to the work of this author. Lendenfeld's nomenclature can not be adopted because it is not based on the idea of serial segmental homology.

The muscles of the wings in Odonata differ from those of all other orders in being inserted upon the bases of the wings instead of upon the neighboring parts of the notum and pleurum. As described by Lendenfeld (1881) the set of eight muscles in each wing are as follows: (1) *Abductor*, (2) *pronator radii primi*, (3) *flexor*, (4) *flexor radii quinti*, (5) *adductor radii quinti*, (6) *pronator*, (7) *supinator*,



(8) *tensor*. All of these but (5) are attached to the sclerites of the pleurum and all but (8) are inserted upon the base of the wing either directly or by long tendons. (5) arises from a process of the notum, while (8) is inserted not upon the wing base but upon neighboring plates of the notum.

## IV. ORTHOPTERA.

*Species studied*.—*Spodromantis guttata* (24, 25, 26, 27, 28, 30, wings 61, 62), Mantid nymph (34, 39), Mantidæ: *Byrsotria fumigata* (29, 32, 33, 34), *Ischnoptera hyalina* (35, 36, 37), *Blattella germanica* (38, 40, wing bases 185, 186), Cockroach wing, diagrammatic (60), Blattidæ: *Microcentrum laurifolium* (39, 41, wings 63, 64), *Anabrus simplex* (42, 43), Locustidæ: *Gryllus pennsylvanicus* (45-50, wings 66, 67, 188), *Gryllotalpa borealis* (wing 65), Gryllidæ *Melanoplus femur-rubrum* (51, 52), *Melanoplus* nymph (55, 56, 58), *Hippiscus phoenicopterus* (53, 54, 57), *Dissosteira carolina* (70, 71, wings 68, 69, 187, 189), *Acridiidae*.

*Characteristics*.—1. Microthoracic sclerites of neck present in nearly all species and often highly developed, consisting of tergal, pleural, and sternal plates.

A good example is afforded by *Spodromantis guttata* (24, 25). The tergal plate is in this species a narrow U-shaped band (24) open posteriorly, but the pleural plates are so large that they greatly encroach upon the dorsal surface of the neck. The pleurites form a series of four sclerites on each side (25), the two of the third pair meeting each other on the mid ventral line. Anterior to these are two transverse sternal plates. The submentum (25, *Sm*) is clearly supported by the pleural and sternal microthoracic sclerites.

The microthorax of Blattidæ, as represented by *Ischnoptera hyalina* (36, 37), is similar to that of the Mantid. Here, however, the tergal sclerites have the more usual form of two narrow longitudinal plate (36). In *Gryllus* (45) the sternal plates are broken up into two transverse series of smaller sclerites. The labium (*Sm*) is here, also, closely associated with the microthoracic plates. *Anabrus simplex* has only one plate on each side of the neck. In the Acridiidae there is a chain of three small cervical sclerites (51, *Mi*) on each side connecting the head with the prothorax.

2. Pronotum in general shows a tendency to crowd out the pleurites of its segment by a downward growth on each side over pleural regions.

In the lower families this is less evident and in the Mantidæ (26) and Blattidæ (29) the propleurum presents all the parts of any complete generalized pleurum, namely, an episternum (*Eps*), an epimerum (*Epm*), a preepisternum (*Peps*), and a trochantin (*Tn*) carrying the ventral coxal articulation (*TnC*), also a pleural suture

(*PS*) separating the episternum and epimerum externally, and a pleural ridge internally. In *Gryllus* (46) the parts are highly modified, but all are represented. The pleural ridge develops a large scapula-like internal plate (*P.1*) lying within the notum. In *Anabrus* the preepisternum is not a distinct plate. It is when the Acridiidae are reached, however, that the greatest modification is found. Here the pronotum (51) extends downward on the side to the base of the leg reducing the episternum (*Eps*) to a small plate in front of the coxa, and the epimerum (*Epm*) to a small plate behind the coxal articulation and fused to the notal rim. A rudimentary trochantin (*Tn*) is also present.

In thus usurping the territory of the pleurum the pronotum has also taken over the function of the former and has become modified accordingly. An inner view (52) shows a prominent pseudopleural notal ridge (*NR*) bearing an arm (*N.1*) near its lower end, just as does a normal pleural ridge (see 44, 55), and terminating below in a pseudopleural coxal process (*NCoP*) to which the coxa is articulated. A large posterior reduplication (*Rd*) back of the posterior groove and ridge (51, 52,  $\pi$ ) overlaps a large part of the mesothorax.

The Acridiid pronotum is thus highly specialized, doing duty as both notum and pleurum, and its subdivision into four transverse parts can not reasonably be cited as a typical example of the quadruple structure of the insect tergum. Yet it is invariably used to illustrate the prescutum, scutum, scutellum, and postscutellum. But it is clearly illogical, as shown in another part of this paper, to offer as "typical" an example that is confessedly not so!

3. Meso- and metapleura closely resemble each other. In most cases illustrations of either one will serve for both.

In the Mantidae (27, 28) the pleural suture (*PS*) is nearly horizontal, but otherwise the meso- and metapleurum is of the typical generalized form. (Compare 27, 28, with text figs. 3 and 4.) In Blattidae (*Byrsotria fumigata* 32) the pleural parts are modified on account of the flattened shape of the body, but in a side view (*Ischnoptera hyalina* 35) the typical structure can be made out. The pleural suture (*PS*) separates the small dorsal epimerum (*Epm*) from the larger ventral episternum (*Eps*). An internal view (33) shows a pleural ridge (*PR*) and arm (*P.1*) in normal relations to the other parts. One preparapterum (*P*) is usually present, and below this an indistinct preepisternum (35, *Peps*) fused with the episternum (*Eps*). At least it is evident that if a preepisternum is present it must occupy some such position. Yet Verhoeff (1903) regards the subdivision (*eps*) on the posterior edge of the episternum (*Eps*) as the "katopleure," while the plate he so designates in the Euplexoptera lies before the episternum. This Euplexopteran sclerite (94, *Peps*), then, is Verhoeff's "katopleure" or the preepisternum (*Peps*) of the

present paper. Now, to homologize the preepisternum of the Euplexoptera (94, *Peps*) with this posterior subdivision (*eps*) of the Blattid episternum (32, 34, 35) requires too much anatomical contortion, and the writer prefers to call the subsclerite in question (*eps*) simply a part of the episternum (*Eps*). Comstock and Kochi (1903) call it the "second antecoxal piece," but it is unnecessary to give it even this designation, which is also undesirable, because misleading.

The trochantin of the Blattidae is likewise subdivided by an oblique suture into a dorsal part (35, *Tu*) and a ventral part (*tn*). The latter is identifiable as the trochantin by its coxal articulation (32, 35, *Tu'*). Comstock and Kochi (1902) call it "the antecoxal piece." Verhoeff (1903) recognizes it as the trochantin.

In the Locustidae (43, 44), the Gryllidae (47) and the Acridiidae (57, 70, 71) the preepisternum (*Peps*) is separated from the episternum by a more or less distinct, though variable, suture. This interpretation may appear doubtful, but a line is distinct in the Acridiid nymph (55, 56) separating a large preepisternum (*Peps*) from the episternum (*Eps*). In *Anabrus* (43) the preepisternum (*Peps*) falls in line with the presternal plate (*Ps*).

A study of nymphal forms (55) shows that the paraptera (*P*), the upper end of the pleural ridge (*PR*), and the wing process are developed only in connection with the adult wing. Short-winged adults, however, such as *Anabrus simplex* (43, 44), have these parts (*P*, *WP*) present, though somewhat rudimentary.

4. Meso- and metanotum similar in most cases and often structurally identical.

In *Blatella* (38, 40) each is so simple in its construction that it could be taken as a diagram of the generalized notal plan of structure. (See text figs. 1 and 2.) Ventrally (40) it presents simple anterior and posterior marginal notal ridges (*LVR*, *PVR*), the latter at the front of a posterior reduplication (*Rd*), and a median V-shaped ridge (*V*) or "entodorsum" of Amans (1885). These three ventral ridges form lines on the surface (38, *anr*, *v*, *pnr*) marking off four apparent notal subdivisions. The metanotum of a short-winged female of *Gryllus pennsylvanicus* is very similar (50); that of a long-winged form differs in shape and has the anterior phragma (*Aph*) highly developed, but is yet of the same fundamental generalized type. In *Microcentum* the V-shaped ridge (*V*) is rudimentary in both mesonotum (41) and metanotum (39), while in the Mantid adult (30) and nymph (31) its apex continues forward as two parallel median ridges to the anterior marginal notal ridge. In Acridiidae (54) there is present an extra ventral ridge (*ss*) consisting of two arms diverging outward and forward from the middle of the posterior notal ridge (*PVR*). The arms of this ridge (*ss*) cross over the arms of the flattened and almost obsolete V ridge (*V*). Their

bases form lines on the dorsal surface (53 *s*) which mark off two oval posterior lateral areas not represented in other families.

If the four divisions of the notum (38), as marked out by the three ventral ridges (40), are called the prescutum, scutum, scutellum, and postscutellum, it must be borne in mind that they are not homologous with the divisions so named in the tergum of Lepidoptera, Hymenoptera, and Diptera. The first division is a narrow marginal strip carrying the prephragma (*Aph*) when this is present. The second is a large bilobed plate carrying both the notal wing processes (*ANP*, *PNP*), the third consists of a triangular median area and of two posterior lateral arms, the fourth is a posterior marginal band consisting of the posterior reduplication (*Rd*) and terminating laterally in the axillary cords (*AxC*). This last subdivision can in no way be identified with the "post-scutellum" of other orders, such as Coleoptera—the representative of this plate is lacking in Orthoptera.

5. Pseudonotum absent in both mesothorax and metathorax. Posterior marginal part of notum, which some entomologists have called "postscutellum" in Orthoptera, *not* the homologue of this plate in other orders.

In many Orthoptera, especially the Acridiidae (57), the first abdominal tergum (*IT'*) presents an anterior subdivision (*It*) whose median dorsal part fuses with the metanotum, but whose lateral parts are mostly free from the metathorax, and on each side enter into the formation of an arm of the first abdominal tergum, extending downward before the auditory organ (*Au*). Internally, on the line between these two subdivisions of the first abdominal tergum, is a prominent ridge. In other Orthoptera this anterior subdivision and the ridge are less developed, in some cases it amounts to only a thinner anterior area which is overlapped by the reduplication of the metanotum.

This abdominal tergum could claim no place in the present discussion were it not that many entomologists have regarded its anterior subdivision as a part of the thorax. Voss (1905), for example, has identified it as the pseudonotum (postscutum, Voss) of the metathorax and the internal ridge as the postphragma. The part in question, however, and the main plate of the first abdominal tergum (57, *It* and *IT'*) are unquestionably anatomically continuous. Moreover, the first is best developed in the Acridiidae, while in Blattidae it is represented only by the weakly chitinized anterior half of the tergum overlapped by the metanotum, a subdivision such as all the abdominal terga present. Berlese (1906) regards it as a part of the first abdominal tergum, but he also thus identifies the pseudonotum (postscutellum) of the metathorax in Coleoptera. The present writer, however, sees no reason for regarding these parts in the two orders as the same. Anyone can see that they are not similar in appearance, and that their



anatomical structure and relation to the surrounding parts are different. Therefore, why not call one a part of the abdomen, which it actually is, and the other a part of the thorax, which it actually is?

6. Wing articulation of typical generalized type, generally four axillary sclerites present, bases of the veins mostly distinct (60-69, 185-189).

In some cases the first axillary is divided into two as in *Locustidae* (*Microcentrum laurifolium*, 63, 64). Voss (1905) describes the same thing in *Gryllus domesticus*. In *G. pennsylvanicus* the neck of the first axillary is joined to the body of the sclerite by very delicate chitin, but the two parts can be demonstrated to be continuous (188).

The venation presents many modifications, but each form possesses some character which, used in strict conformity in all the families, furnishes a clue for the identification of the veins. (See Plates 47, 48, 65.) An important character is the location of the first anal fold (*AF*) in which the vena dividers (*D*) is located when the latter is present (58, 69, 185, 186, 189, *D*). It will be noticed that in all cases, except in the fore wing of *Gryllus* (67) the first anal vein (*LA*) lies in front of the anal fold (*AF*) or the vena dividers (*D*) and is independent of the rest of the anals at the base. That this is a nymphal condition is shown by the nymphal Mantid wing (59). Comstock and Needham (1898, '99) have illustrated the same thing in the wing of a young cockroach. Thus the first anal vein can be identified by its lying before the first anal fold and by its basal independence. Likewise its absence can be proved in the fore wing of *Gryllus* 67. The anal fold here appears to lie before the cubitus (*Cu*) but basally it will be found originating behind this vein. In the hind wing of the same species (66) the anal fold and first anal are normal. The first anal is frequently branched (60, 64), while in *Dissosteira* it fuses basally with what appears to be the vena dividers of the hind wing (69, 189).

The cubitus (*Cu*) and media (*M*) show a tendency to unite with each other at their bases, as illustrated in *Blattidae* (60), *Mantidae* (62), *Locustidae* (63, 64), *Gryllidae* (67), and *Aceridiidae* (68, 187). In the hind wings of *Gryllus* (66) and *Dissosteira* (69) the media (*M*) is fused for some distance with the radius (*R*). That the vein labeled *M* is the media in these wings can be determined by comparison with the venation of the fore wings (67, 68), where the media is separate from the radius at least to a point proximal to its union with the cubitus. In the fore wing of the *Aceridiidae* (*Dissosteira* 68) the costa (*C*) forms the anterior margin, while the subcosta (*Sc*) is clearly double from near the base. It is, hence, clear that in the hind wing the costa is absent and that what is here the marginal vein is the first branch of the subcosta (*Sc*).

It is interesting to observe that the tegula (*Tg*) is represented in both the fore and hind wings of nearly all Orthoptera by a small hairy pad on the axillary membrane between the base of the costa and the attachment to the notum.

#### V. PLECOPTERA.

*Species studied.*—*Pteronarcys californica* adult (72, 75, 78, 79, wings 182, 183, 184). *Taniopteryx fasciata* adult, *Perla* sp. nymph (73, 74, 76, 77). *Acroneuria* sp. nymph (81), *Isogenus* sp. nymph (80).

*Characteristics.*—1. Microthorax not well developed, consisting generally of a chitinous band or plate on each side of neck.

2. Trochantin (*Tn*) of prothorax in both nymphs (73) and adults (72) inserts itself between coxa and true pleurum formed of episternum (*Eps*) and epimerum (*Epm*). Upper part of trochantin (*Tn*) then takes on both the function and appearance of the displaced pleurum. It articulates with dorsal edge of coxa by a special condyle (*Tn CxP*), presents externally a pseudopleural trochantinal suture (72, *Tn S*) and internally a pseudopleural trochantinal ridge (74, *Tn R*). Continuing above the latter on true pleurum is the real pleural ridge (*PR*).

3. Trochantin of both mesothorax and metathorax fused in adults (78, 79, *Tn*) with episternum (*Eps*), apparently not taking part in coxal process (*CxP*). A nymph of *Acroneuria* (81) is similar but one of *Isogenus* (80) presents a very typical trochantin (*Tn*) in the mesothorax.

4. Wing bases very simple, parts of typical arrangement (182, 183). A triangular plate (*C*) of head of costa articulates with parapterum (78, 79, *P*). Wing venation shown by figs. 183, 184.

5. Meso- and metanotum divided topographically into regions (75) but not by lines or sutures. V-ridge absent.

6. Plecoptera differ from Orthoptera in specialized condition of prothoracic pleurum and in development of pseudonotum in both meso- and metatergum.

#### VI. CORRODENTIA.

*Species studied.*—*Cerastospinus venosus* (82).

*Characteristics.*—1. Microthorax presents elongate plate on each side of neck, connecting with triangular lobe on posterior rim of head, and with an arm on edge of prothoracic episternum.

2. Prothorax reduced, but all plates present except a preepisternum. Epimerum largest plate. Trochantin does not articulate below with coxa.

3. Dorsal plates of meso- and metathorax (mesonotum and pseudonotum and metanotum and pseudonotum) all fused so that meso- and metaterga are solidly continuous.

4. Meso- and metapleurum (82) alike. One preparaterum (*P*) present in each forming large lobe of episternum. Epimerum fused above with pseudonotum (*PN*).

#### VII. HEMIPTERA.

*Species studied.*—*Benacus haldemanum* (83, 84, 85, 86, 87, 88, 89, wing bases 190, 191), *Amorgius americanum*, *Belostomida*.

*Characteristics.*—The following characteristics may not be general to the Hemiptera, for there evidently exist numerous structural modifications within the order. The drawings of *Benacus haldemanum* can not serve as more than a basis for a comparative study, but they illustrate the agreement of the Hemipteran thorax with the fundamental plan of that in other insects.

1. Microthoracic plates absent.
2. Trochantins (*Tn*) present in each segment, but hidden, together with bases of coxæ, by the produced edges of the pleurites (83, 85).
3. Anterior coxæ articulated to condyls carried by pronotum (83, *CxP*).
4. Posterior coxæ articulated to a condyle of the metaepimerum (84, 89, *h*), which is inserted between the coxa and the true pleural coxal process (*CxP*).
5. Preparaptera not distinct from episternum (85, 89). No postparaptera.
6. Episternum of metathorax divided into an upper and a lower sclerite (89, *Eps*, *Eps*).
7. Scutellum of mesonotum forms a large triangle between bases of fore wings. Mesopseudonotum absent.
8. Metanotum distinctly divided into three transverse parts by transverse lines (87, *pse*, *set*, *scl*). A pseudonotum (87, 88, *PN*) present, very narrow mesially, expanded laterally where fused with epimera (*Epm*).
9. First abdominal tergum (87, 88, *IT*) a narrow bar fused with metapseudonotum, expanded laterally, bearing the spiracles (*I Sp*) and phragmal arms (*I Ph*).
10. Wing bases shown by 190 and 191. *C*, *Sc*, and *R* form large detached sclerite at humeral angle of hind wing (191) though not detached in fore wing (190). Third axillary divided and of unusual shape in fore wing (190, *3 Ax*), simple in hind wing.

#### VIII. EUPLEXOPTERA.

*Species studied.*—*Spongiphora apicidentata* (90–94, 98, 100), *S. brunneipennis* (96).

*Characteristics.*—This order has been specially studied by Verhoeff (1902, 1903a). The present writer has elsewhere (1908) made a comparison of the Euplexopteran thorax with that of Orthoptera and

Coleoptera. Such a comparison shows many more points of resemblance to the Coleoptera than to the Orthoptera, but at the same time the similarity is of such a nature that it may be secondary rather than phylogenetic.

1. Microthorax well developed, presenting tergal, pleural, and sternal plates (93), one of the latter almost gular in position.

2. Presternum consisting of two plates (*Ps*) in all three segments lying before or beside the anterior angles of the sternum (91, 94, 98).

3. A preepisternum (*Peps*) well developed in mesothorax (94).

4. Trochantin (*Tn*) present in all three segments (91, 94, 98).

5. Propleurum (91) and mesopleurum (94) similar, differing from metapleurum (98).

6. Metapleurum (98) in appearance similar to that of Coleoptera. First preparapterum (*IP*) fused with front of episternum (*Eps*) and bears internally large pronator disc (100, *PD*).

7. Mesonotum (90, 92) simple, mesopseudonotum lacking. Metanotum (96, *N*) complex, presenting median groove fringed with recurved bristles (*G*). Metapseudonotum (*PN*) present, though fused with first abdominal tergum (*IT'*).

8. A small rod in wing base connects with parapteral region in mesothorax (90, *n*) and with second preparapterum (*2P*) in metathorax (98, 100, *n*).

#### IX. COLEOPTERA.

*Species studied*.—*Calosoma scrutator* (102, 103, 110, 113, 127, 132, 133, wing base 193, 197), Carabidae; *Dytiscus dauricus* (107, 108, 114, 128, 131, 136, wing base 192), Dytiscidae; *Hydrophilus triangularis* (105, 111, 112, 125, 134, wing base 198), Hydrophilidae; *Silpha surinamensis* (106), Silphidae; *Melolontha vulgaris* (117, 121, 135, 138, 139, wing base 195, 199), Scarabaeidae; *Buprestis aurulenta* (95, 99, 104), Buprestidae; *Tetropium glutinum* (123), *Cyllene robinia* (97, 101, 116, 119, 129, 130, 140, wing base 194), Cerambycidae; *Dendroctonus valens* (118, 120, 122, 124, 126), Scolytidae.

*Characteristics*.—1. Microthoracic plates rudimentary (95) or absent.

2. Prothoracic and mesothoracic pleura resemble each other more than they do the metathoracic pleurum. Pleurites of the first two vertical or oblique, those of the last horizontal.

3. Prothoracic pleurites commonly fused with each other and with tergum and sternum, but not reduced in size.

4. Mesothoracic pleurites (97, 101, 102, 105, 106, 107, 109) always distinct, usually oblique. Wing process (*WP*) often hidden by prominent upper end of episternum, but easily seen on inner surface (101, 103, 108) as is also its relation to pleural ridge (*PR*). Epimerum (*Epm*) commonly with a dorsal subdivision (*cpm*), and



episternum (*Eps*) often divided into several parts by vertical ridges or lines (102, 109).

5. Metathoracic pleurites horizontal or nearly so (110–121). Wing process (*WP*) a prominent oblique arm arising from anterior ends of pleurites, lying just behind and parallel with a similar arm from the preparapterum which also takes part in supporting the wing. (See description under 8.) Usually a more or less prominent supraepimeral plate present (111–121, *epm*) to which the ends of the metapseudonotum are connected.

6. Trochantin (*Tn*) present in prothorax and mesothorax, but is usually a small sclerite at base of coxa (99, 104) concealed in coxal cavity formed by projecting pleurites. In Silphidae (106) and Buprestidae (109) it is exposed on surface of mesothorax. Lacking in metathorax.

7. Only one preparapterum (*P*) present in either segment. Postparapterum lacking. Preparapterum of mesopleurum usually a small plate or rod lying before the wing process (102, 103, 107, 108). Sometimes it bears a pronator muscle disk (101, *P*, *PD*).

8. Preparapterum of metathorax in most beetles fused with an anterior subdivision (*eps*) of episternum (*Eps*) as in *Cyllene* and *Dendroctonus* (116, 118, *P* + *eps*), making, with the wing process (*WP*), two conspicuous wing-supporting arms. In lower forms, like *Calosoma* (110, 113) and *Dytiscus* (114, 115) the parapterum (*P*) and its disc (*PD*) are entirely free from the episternum (*Eps*) though closely articulated to front of wing process (*WP*). Other forms, such as *Hydrophilus* (111, 112) and *Melolontha* (117, 121), show an intermediate condition in which the line of fusion is distinct.

9. Mesonotum (125, 127, 128, 129) generally presents a triangular scutellar area between bases of elytra. Mesopseudonotum lacking unless represented by two small plates (127, 128, 131, *q*) connecting mesonotum with metanotum.

10. Metanotum in lower families like Carabidae (132) and Dytiscidae (136) distinctly divided into three transverse parts (*pse*, *set*, *sel*). The first or prescutum (132, 136, *pse*) carries the prephragma (*Aph*) and the anterior notal wing processes (*ANP*); the second or scutum (*set*) is divided transversely into an anterior and a posterior plate by a large transverse ventral ridge (133, 137, *w*) peculiar to the Coleoptera and forming lines (132, 136, *w*) on the surface, while each of these is divided again into separated lateral regions by a median interlocking of the prescutum (*pse*) and scutellum (*sel*). Thus the scutum consists of four well-marked subdivisions, the posterior pair of which carries the posterior notal wing processes (*PNP*). The scutellum (*sel*) consists of a median triangular area produced into a tongue on the floor of the median notal groove (*G*), formed by the endodorsum or ventral V-shaped ridge (133, 137, *V*),

and of two slender lateral strips forming the posterior margin of the notum and ending in the axillary cords (*AxC*).

This simple *Calosoma-Dytiscus* plan (132, 136) is distorted by modifications in the higher families, but a serial change can be traced through *Hydrophilus* (134), *Melolontha* (135, 138), and *Cyllene* (140).

11. Pseudonotum of metathorax (*PV*) well developed in all beetles (132-137, 139, 140), carrying the postphragma (*Pph*) and articulating by its extremities (*i*) with epimera of metathorax. Absent in Coleopteran pupæ (122, 123).

12. Elytra (*El*) articulated to mesothorax by the ordinary three axillary sclerites, though the first and second are sometimes fused (127, 128).

13. Wing bases of usual construction (192, 193, 194, 195, 198). Head of the costa (*C*) frequently separated from main shaft of the vein (197) and attached to the subcosta (*Sc*) by a process fitting into a cavity in the head of the latter. Venation poorly developed (196). Axillaries normal, sometimes with a small accessory piece (199).

#### X. NEUROPTERA.

*Species studied*.—*Corydalus cornuta* (142, 143, 144, 145, 147, wing bases 200, 201).

*Characteristics*.—1. Posterior segment of gula projects beyond rim of head and is entirely surrounded by membranous sutures, thus strongly suggesting a microthoracic origin. Between head and prothorax is a wide collar-like band open dorsally, mostly concealed within rim of pronotum. Perhaps this collar is microthoracic, but possibly it is presternum of prothorax.

2. Prothorax elongate, depressed. Notum and sternum separated by wide infolded pleuro-tergal membrane. Pleurites reduced to small plates, episternum fused with sternum. Procoxa simple, cylindrical, not double as in meso- and metathorax.

3. Meso- and metanotum sufficiently shown by figs. 142 and 143. Both notal wing processes carried by scutum.

4. Meso- and metapleurum of the adult similar (147). One prepapapterum (*P*), fused with episternum. Trochantin (*Tu*) large. Coxa of two parts, a ventral segment (*Cx*) carrying the trochanter, and a dorsal posterior segment (*cpm*). A study of the pupa (145) and the larva (144) shows that the upper coxal segment is simply a detachment of the epimerum (*Epm*) fused upon the coxa (*Cx*). In the larva (144) epimerum is divided (*Epm*, *cpm*); coxa (*Cx*) is simple, as in prothorax of adult. In pupa (145) lower subdivision of epimerum (*cps*) extends downward and attaches to rear side of coxa. In adult (147) this separation completed and lower plate (*cpm*) of epimerum (*Epm*) entirely detached from the latter and intimately fused with coxa.

This double nature of the meso- and metacoxæ is common to Neuroptera, Mecoptera, Trichoptera, and Lepidoptera, and it has often been adduced as evidence of the double nature of the entire segment. Since, however, it can be shown in all these orders to be a purely secondary adult character, it is evident that it has no such significance whatever.

5. Wing base very simple in the pupa (141). Articular elements and bases of the veins of typical shape in adults (200, 201).

#### XI. TRICHOPTERA.

*Species studied.*—*Neuronina ocellifera* (146, 148), *Platyphylax subfasciata*, *P. designata*, larvæ and pupæ of unknown species.

*Characteristics.*—1. Only one preparapterum (148 *P*) present, fused with episternum. Pronator disc carried by upper edge of episternum.

2. Trochantin (*Tn*) of meso- and metathorax crowds episternum (*Eps*) from coxal articulation.

3. A wing of the meso- and metasternum (*S*) extends dorsally before the trochantin (*Tn*) to the episternum (*Eps*).

4. Meso- and metathorax similar to each other in size and structure.

5. Meso- and metacoxæ (*Cr*) of adult with a posterior segment (*cpm*) as in Neuroptera. This can be shown by a study of the pupa (146) to be a detached piece (*cpm*) of the *epimerum* (*Epm*), which has extended downward behind the coxa and fused upon it.

The Trichoptera stand in a position intermediate between the Neuroptera and the Lepidoptera. The resemblance of the Trichopteran pleurum to that of a generalized moth like *Phassus* (149) is very striking.

#### XII. LEPIDOPTERA.

*Species studied.*—*Phassus argentiferus* (149, 150, 151, 152, wing bases, 202, 203), *P. triangularis* (153, 154). Cossidæ; *Protoparce cingulata* (155–159, wing base, 204). Sphingidæ; *Citheronia regalis*, Citheroniidæ.

*Characteristics.*—1. Microthorax represented by one or two sclerites on side of neck (152 *mi*, *mi*).

2. Pronotum well developed in lower families (152 *N*); reduced and longitudinally compressed in higher families, often forming two flat lateral lobes which even become constricted at the base into two stalked plates, the patagia. The patagia are specially well developed in *Agrotis*. A comparative study would show them to be simply developments of the notum, and there is no ground for regarding them as homologues of the wings, nor even of the tegulæ.

3. Propleurum narrow (152). Epimerum (*Epm*) specially reduced, generally obsolete. Episternum (*Eps*) prolonged upward as a narrow prenotal band, overlapped by edge of notum.

4. Prothoracic coxa not articulated to true coxal process, but to a small detached plate in *Phassus* (152 *p*) which in *Protoparce* and *Citheronia* is fused with lower end of episternum.

5. Meso- and metathoracic coxæ (149, 153) double in adults as in Neuroptera and Trichoptera, consisting of an anterior true coxa (*Cx*) and of a posterior plate (*cpm*), undoubtedly derived from the epimerum (*Epm*) as in *Corydalus* and *Neuronia*. The coxæ have but little motion upon the pleurum and the principal movement of the base of the leg is in the articulation between the coxa and the trochanter.

6. Trochantin present in both meso- and metathorax (149, 153, 154, 158, 159, *Tn*), but more or less completely fused with episternum (*Eps*) above, and always closely attached to a wing of sternum (*S*) in front. This is exactly the same as in *Corydalus* (147) and *Neuronia* (148). Lower end sometimes projecting as a free point articulating with ventral rim of coxa and sometimes obsolete.

7. Only one preparapterum present (149, 153, *P*), and it is fused with episternum. Pronator disc (154, *PD*) carried by upper edge of episternum.

8. The pleural wing process of mesopleurum (153, 154, 159, *WP*) bears a large anterior arm (*tg.1*) serving as a prop for the tegular plate of the notum (150, 156, *tg*).

9. Mesothoracic notum (150, 156) distinctly subdivided into a prescutum (*pse*) carrying the prephragma (155, *Aph*), a scutum divided into two lateral lobes (*set, set*) carrying the anterior notal wing processes (*ANP*) and, in *Phassus*, the posterior processes also (150, *PVP*), and into a scutellum (*scel*) forming a posterior triangle (*scel*) whose lateral angles terminate in the axillary cords (*AxC*). Probably in most families the posterior notal wing processes (*PVP*) would appear to belong to the scutellum (*scel*) as in *Protoparce* (156).

10. Tegulae greatly developed in mesothorax (149, 150, 202, *Tg*) and attached to a special tegular plate of the notum (149, 150, 156, *tg*) supported by the tegular arm (153, 154, 159, *tg.1*) of the wing process (*WP*).

11. Metanotum in lower forms like Cossidae (151) similar to, though smaller than, the mesonotum (150). In higher families it becomes very much shortened antero-posteriorly, as shown by *Protoparce* (157), and greatly reduced in proportion to the mesonotum (156).

12. A pseudonotum (*PN*) present in both meso- and metathorax, though depressed and mostly hidden (149). In mesothorax (150, 156, *PN*) it carries a large postphragma (*Pph*). In metathorax (151, 157) postphragma (*Pph*) is smaller and fuses with first abdominal tergum (149, 151, *IT*).



13. In wing base (202, 203) media (*M*) and cubitus (*Cu*) fuse with base of radius (*R*). Axillaries of ordinary structure (202, 203, 204).

14. The jugum (202, *Ju*), present in lower families, is simply a lobe of anal region of fore wing and is supported by last anal vein (34).

15. The frenulum (204, *Fr*) consists of a spine or bunch of bristles developed on enlarged base of costa (*C*) of hind wing.

### XIII. HYMENOPTERA.

*Species studied.*—*Cimbea americana* (161–166, wing base 205), *Parasiloba* sp. (160), Tenthredinidæ; *Sirex flavipennis* (161, 171, 172, wing bases 206, 207) Siricidæ; *Pepsis* sp. (168, 169, 170, wing bases 208, 209) Pompilidæ; *Sphæcius speciosus*, Bembecidæ.

*Characteristics.*—1. Pronotum (*N*<sub>1</sub>) attached to mesothorax (160, 163, 169) and but loosely connected with prothoracic pleural parts (160, 162, 168), except in *Sirex* where prothoracic parts retain normal relations (171).

2. Trochantin absent as a distinct sclerite in all three segments.

3. Epimerum of prothorax rudimentary, forming merely a narrow posterior marginal rim on episternum (160, 162, 168, 171, *Epm*).

4. Mesonotum divided into three distinct divisions (160, 161, 163, 170, *pse*, *set*, *scl*), first of which (*pse*) sometimes entirely concealed by pronotum (169, *N*<sub>1</sub>). Scutum (161, 170, *set*) carries anterior notal wing processes (*ANP*) while scutellum (*scl*) carries posterior wing processes (*PNP*) and axillary cords (*AxC*). Mesopseudonotum (160, 161, 163, 169, 170, *PN*<sub>2</sub>) carries large postphragma (161, 163, 170, *Pph*) projecting downward and backward into metathorax.

5. Metathorax well developed and of normal shape in *Cimbea* (164) presenting all the principal pleural and tergal parts (*Eps*, *Epm*, *set*, *scl*, *PN*). In *Parasiloba* (160) parts somewhat larger, but pleural suture (*PS*) almost horizontal. In all higher Hymenoptera (*Pepsis* 169) the metapleurites (*Eps*, *Epm*) are elongate, entirely fused with each other, obliterating the metapleural suture, and continuous with the pseudonotum (*PN*<sub>3</sub>).

6. First abdominal tergum (*IT*) in *Parasiloba* (160) somewhat more separated from second abdominal tergum (*IIT*) than from the metapseudonotum (*PN*<sub>3</sub>). In *Cimbea* (164) entire first abdominal segment (*IT*) attached to posterior rim of the metathorax and but loosely connected with rest of abdomen (166). In all higher families (*Pepsis* 169) the first abdominal tergum (*IT*) solidly incorporated into metathoracic wall and virtually a part of metathorax, the peduncular constriction occurring between it and second abdominal segment (*IIT*). This is probably the most distinctive character of the

Hymenoptera. The first abdominal segment is known as the *median segment* ("segment mediaire" of Latreille) and can always be identified by its spiracles (160, 164, 167, 169, *ISp*).

7. Tegulae of fore wings developed as in Diptera into large scale-like plates overlapping humeral angles of wings (160, 161, 163, 169, 170, 205, 206, *Tg*). In hind wings they are hairy pads as in Orthoptera (207, 209, *Tg*).

8. Four axillaries nearly always present as in Orthoptera (205, 206, 207, 208), the first and fourth articulating with notal wing processes.

9. Head of costa in fore wings (205, 206, 208, *C*) separated as a humeral plate with head of subcosta (*Sc*) attached. Subcosta (*Sc*) a separate vein in fore wing of *Sirex* (206), in other forms (205, 207, 208, *Sc*) shortened to a basal piece between bases of costa (*C*) and radius (*R*) and fused with the detached costal head (206, 207, 208). In hind wing of *Pepsis* (209) bases of the costa (*C*), subcosta (*Sc*), radius (*R*), and media (*M*) all fused into one common head.

There is nothing in the basal structure of the veins that would discredit Comstock's interpretation of the Hymenopteran venation, though it probably does not indicate whether *M* is fused with *R* or is lacking.

#### XIV. DIPTERA.

*Species studied*.—*Holorusia grandis* (174–178, wing base 210, base of halter 211), Tipulid pupa (173), Tipulidae; *Tabanus atratus* (179, 180), Tabanidae; *Calliphora vomitoria* (wing base 212) Muscidae.

*Characteristics*.—1. Two cervical sclerites present on each side of neck in *Holorusia* (174) and *Tabanus* (179), and several ventral sclerites in the latter and in *Calliphora*.

2. Prothorax reduced but episternum and epimerum (174, 179, *Eps*, *Epm*) present, and in *Holorusia*, pronotum (174, *N*<sub>1</sub>) formed of two distinct subdivisions (*set* and *sel*).

3. Trochantin absent in all three thoracic segments, unless the small plate (174, 179, *Tn*?) of the prothorax is a rudimentary trochantin.

4. In meso- and metathorax of *Holorusia* (174) each sternum (*S*<sub>2</sub>, *S*<sub>2</sub>, *S*<sub>3</sub>) presents a precoxal and a postcoxal plate connecting with the episternum (*Eps*) and the epimerum (*Epm*) respectively. This is true only of the mesosternum (*S*<sub>2</sub>, *S*<sub>2</sub>) of *Tabanus* (179).

5. Mesopleurum of *Holorusia* of simple, typical structure (174, 176, 178); but in *Tabanus* (179) and in all higher Diptera episternum divided into a large anterior plate (*eps*), and a less conspicuous posterior part (*Eps*) entering into formation of wing process (*WP*). The relation of the anterior plate (*eps*) to the first spiracle (*Sp*<sub>1</sub>) and to the other neighboring parts is so nearly identical with that of the single, undivided episternal plate of *Holorusia* (174, *Eps*<sub>2</sub>)

that it can not be doubted that the sclerite in question belongs to the episternum. Some authors have regarded it as a part of the mesosternum. Among the latter are Lowne (1902), who calls it the "lateral plate" of the mesosternum. Hewett (1907) interprets it in the same way. Hammond (1881) identifies it as the "parapterum," but this is certainly stretching homologies too far, especially since a true preparapterum is present in the mesothorax (174, 176, 178,  $P$ ) of *Holorusia* and two in that of *Tabanus* (179,  $1P$ ,  $2P$ ). Berlese (1906) regards the plate as the mesoepisternum, as also does Crampton (1909). A comparison of figs. 174 and 179 certainly suggests nothing else than that the mesoepisternum ( $Eps_2$ ) of the former is simply divided in the latter into two plates ( $eps_2$  and  $Eps_2$ ).

6. Mesonotum very large (174, 175, 179, 180) and in *Holorusia* (175) definitely subdivided into prescutum ( $pse$ ), scutum ( $set$ ), and scutellum ( $sel$ ), but in *Tabanus* (179, 180) first and second parts not so distinctly separated ( $pse$ ,  $set$ ). The scutum carries the anterior notal wing processes ( $ANP$ ) and the scutellum the posterior wing processes ( $PNP$ ) and axillary cords ( $AXC$ ).

7. Mesopseudonotum very large in *Holorusia* (174, 175,  $PV_2$ ), consisting of median and two lateral subdivisions, the "mediophragmite" and "pleurophragmites" of Crampton (1909), the latter connected with epimera (174,  $Epm$ ). Present in pupa (173) as plate ( $PV_2$ ) between the two wing-bearing nota ( $N_2$ ,  $N_3$ ). In *Tabanus* (179) mesopseudonotum ( $PV_2$ ) narrow, reaching undivided down the side to epimerum ( $Epm_2$ ), carrying posteriorly an extremely large phragma ( $Pph_2$ ) extending downward and posteriorly into abdomen, making a large convex wall almost shutting off the cavity of abdomen from that of thorax.

8. Metathorax always reduced, but with the two principal pleural plates well developed (174, 177, 179  $Eps_3$ ,  $Epm_3$ ) and forming a normal wing process ( $WP_3$ ) supporting the halter ( $III$ ), in every way comparable with the parts of the mesothorax (176, 178) except that the preparaterum ( $P$ ) is lacking. Metanotum (174, 179,  $N_3$ ) reduced to a narrow band. Metapseudonotum ( $PV_3$ ) present and continuous with the epimera ( $Epm_3$ ).

9. Axillaries normal, present in both wing (210, 212) and halter (211). The detailed structure of the base of the latter (211) leaves no doubt that it is simply a modified wing, while a study of a Tipulid pupa (173) shows that the halter ( $W_3$ ) is truly wing like in its origin.

10. Tegula (210, 212,  $Tg$ ) developed as a large hairy scale covering humeral angle of wing.

11. Alula a specially developed lobe or lobes of the axillary membrane of the wing (212,  $Al$ ) bordered by the axillary cord ( $AxC$ ).



## VIII. GLOSSARY AND SYNONYMY.

The following principles have been used in the selection, application, and spelling of the anatomical terms here explained:

1. The same names are repeated in each segment on corresponding parts and distinguished in each by the prefixes *pro*, *meso*, or *meta*.

2. The terms proposed by Audouin (1824) are retained in all cases except where there are very strong reasons for discarding any one of them, as in the substitution of *cutosternum* Chabrier (1820) for *entothorax* Audouin, and of *pseudonotum* Verhoeff (1903) for *post-scutellum* Audouin as the general name of the posterior tergal plate. (See rule 8.)

3. Parts not named by Audouin have been given names selected from the works of other anatomists when such names are descriptive of the parts to which they are applied or are in accord with the general system of naming the other parts. Priority is not recognized because it would involve the retention of too many inappropriate or cumbersome terms.

4. In naming the wing veins and their branches, the names and venational system of Comstock have been used in all cases.

5. No attempt has been made to give, in the synonymy, the equivalence of terms used by systematists in different orders. Their systems of nomenclature too often show an absolute disregard for, or ignorance of, comparative anatomy.

6. The term *dorsum* is used to designate the entire back of the insect or of any part or segment, and the term *center* is applied in like manner to the ventral surface.

7. The names *tergum*, *pleurum*, and *sternum* are used to designate all the chitinous parts of the morphological dorsal, lateral, and ventral surfaces, respectively, in any segment; the individual plates in each are called *tergites*, *pleurites*, or *sternites*. An exception to this is the use of the word *sternum*, applying also specifically to the second sternite of any segment.

8. The term *notum* is applied to the primitive wing-bearing plate of the dorsum, and is synonymous with *tergum*, except where, as in the meso- and metathorax of most adult insects, the dorsum acquires a secondary tergal plate back of the wing-bearing notum. This secondary plate is called the *postnotum* or *pseudonotum*.

9. The prefixes *pro*, *meso*, and *meta* are used only to signify that the part so designated belongs to the prothorax, mesothorax, or metathorax.

10. The prefixes *pre* and *post* are used to indicate the anterior and posterior parts, respectively, of any one segment.

11. The prefix *præ* is discarded in favor of *pre*.



12. The Greek termination *on* is replaced in all cases, for the sake of uniformity, by the Latin ending *um*. Thus, *epimeron* instead of *epimeron*, *elytrum* instead of *elytron*.

*Abdominal sterna* (IS-AS).—The ventral plates of the abdominal segments. The eighth and ninth carry the gonapophyses—the pieces of the ovipositor or sting.

*Abdominal terga* (IT-AT).—The dorsal plates of the abdominal segments. In Hymenoptera the first is fused with the metathorax, and is called the median segment or "segment mediaire" of Latreille.

*Accessory coxal plates* (Cra).—Small sclerites sometimes occurring in the membrane at the base of the coxa, especially between the coxa and the trochantin. *Complimentary coxal plate* Crampton (1909).

*Accessory trochantinal plate* (Tua).—A small sclerite sometimes at the coxal end of the trochantin, but more closely associated with the trochantin than with the coxa.

*Alula* (Al).—The membranous lobe or lobes at the base of the wings of Diptera and the elytra of some Coleoptera, consisting of an expansion of the posterior part of the axillary membrane. *Alula* Kirby and Spence (1826). *Anallappen* Voss (1905).

*Anal fold* (AF).—The line of folding between the anal area and the preceding part of the wing. The *vena dividens*, when present, is developed as a secondary vein in this fold. In Orthoptera the fold is nearly always *behind* the first anal vein, or starts behind it at the base of the wing.

*Anal veins* (A or 1A, 2A, etc.).—All the wing veins caudad of the cubitus or fifth primary vein.

*Anterior notal ridge* (ANR).—The anterior ventral marginal or submarginal ridge of any notum, simple in immature forms, carrying a variously developed prephragma in most adults, and often forming a submarginal line (*anr*) on the dorsal surface of the notum.

*Anterior notal wing process* (ANP).—The anterior lateral process of the notum hinging with the wing by the first axillary sclerite of the wing base. *Apophyse humerale* Chabrier (1820). *Axillifère* Straus-Dürckheim (1828). *Tergelhebel* Voss (1905). *Precondilo* Berlese (1906).

*Anterior phragma* (Aph).—See *Prephragma*.

*Apodeme*.—Any internal chitinous projection of the body wall whether a ridge, an arm, or a pedunculated disc or cup.

*Auditory organ of locust* (Au).—The tympanum on the side of the first abdominal segment in Acridiidae.

*Axillaries* (1, 2, 3, 4; 1Ax, 2Ax, 3Ax, 4Ax; indicated also by *transverse shading* for the first and fourth, *oblique* for the second, and *longitudinal* for the third). The three, or sometimes four, small sclerites at the base of the wing articulating it to the body. (See

first axillary, second axillary, third axillary, and fourth axillary.) *Ossclels radicaux* Chabrier (1820). *Epidemes d'articulation* (?) Audouin (1824). *Epauliers* of elytrum, *axillaires* of wing, Straus-Dürkheim (1828). *Artes* Kirby and Spence (1826). *Tergalplatten* and *analgeleknplatten* Voss (1905). *Pezzi articolari* Berlese (1906).

*Axillary cord* (*AæC*).—The thickened and usually corrugated posterior cord-like edge of the anal membrane of the wing normally arising on each side from the posterior lateral angle of the notum and thus serving as a mark of the posterior limits of the latter. *Ligamentum alæ* Lendenfeld (1881). *Cord-like structure* Comstock and Kellogg (1902). *Ligamento* Berlese (1906).

*Axillary membrane* (*AæM*).—The membrane of the wing base, specially evident as the very delicate membranous expansion at the posterior basal angle of the wing. The *alula* are extreme enlargements of this part of the axillary membrane.

*Axillary sclerites*.—See *Axillaries*.

*Cercus* (*Cr*).—The cerci are the appendicular organs of the tenth abdominal segment. *Cercus* Kirby and Spence (1826).

*Cervical sclerites* (*mi*).—The sclerites of the microthorax situated in the membrane of the neck. *Pieces jugulaires* Straus-Dürkheim (1828). *Prothoracic paraptera* Newport (1839). *Cervical sclerites* Comstock and Kellogg (1902). Sclerites of *microthorax* Verhoeff (1902). *Vorplatten* of prothorax, Börner (1903). *Pezzi ingulari* Berlese (1906).

*Costa* (*C*).—The first vein of the wing, usually forming its anterior margin.

*Coxa* (*Cx*).—The basal segment of the leg. *Clavicula* (prothorax), *coxa* (meso- and metathorax) Kirby and Spence (1826). *Hanche* Straus-Dürkheim (1828). *Coxa genuina* Walton (1900).

*Coxal cavity* (*CæC*).—The cavity on the outside of the body formed by the projecting pleurites and sternum, sometimes inclosing the coxa as in a socket.

*Coxal process* (*CæP*).—See *Pleural coxal process*.

*Coxo-axillary muscle*.—The muscle extending from a large disk of the wing base, usually attached to the second axillary, to the anterior rim of the coxa. *Muscle coxali-axillaire* Chabrier (1820).

*Cubitus* (*Cu*).—The fifth principal vein of the wing.

*Dorsum*.—The entire back of the insect or of any part or segment. *Dorsum* Audouin (1824). Crampton (1909). Used in various ways by other authors, sometimes to signify the entire upper surface, sometimes synonymous with *notum* or *tergum* and even with *scutum*.

*Elytrum* (*El*).—The anterior wing of Coleoptera and Euplexoptera. *Elytrum* Fabricius (1778), Kirby and Spence (1826). *Elytron* common spelling.

*Entodorsum* (*V*).—The ventral V-shaped ridge of the notum, usually separating the scutum from the scutellum. *Entodorsum* Amans (1885).

*Entopleurum* (*PR* and *P.1*).—The apodeme on the inner face of the pleurum along the line between the episternum and the epimerum, consisting of the *pleural ridge* and *pleural arm* (which see). *Entopleuron* Amans (1885), Crampton (1909).

*Entosternum* (*Fu*).—The internal skeleton of the sternum (See *Furca*). *Entosternum* Chabrier (1820), Amans (1885). *Entothorax* Audouin (1824).

*Entothorax*.—The internal skeleton or apodemes of the thorax, including the *entodorsum*, *entopleurum*, and *entosternum*. (Audouin applied the name "entothorax" to the sternal apodemes alone.)

*Epimeral paraptera* (*3P*, *4P*).—The small plates in the pleural membrane below the base of the wing and posterior to the pleural wing process. Commonly there is but one present, though two occur in some of the Plecoptera. (Also called *postparaptera*.) *Costale* Straus-Dürckheim (1828). *Costa* Lowne (1892), Hewett (1907). *Epimeralgelenkplatten* Voss (1905). *Postepimeron* Snodgrass (1908). *Costal sclerite* and *posterior costal sclerite* Crampton (1909).

*Epimerum* (*Epm*, *cpm*).—The principal pleural plate lying behind or above the pleural suture and pleural ridge, in general forming the posterior half of the pleurum. Its posterior dorsal angle connects with the postnotal plate of the tergum. In the metathorax of Coleoptera the epimerum commonly presents a distinct dorsal subdivision (*cpm*), the "parapleur" of Kolbe (1889). *Epimère* Audouin (1824). Posterior plate of *scapularia* in mesothorax, of *parapleura* in metathorax, Kirby and Spence (1826). *Seconde iliaque* of mesothorax, *seconde ischion* of metathorax, Straus-Dürckheim (1828). *Postpleuron* Amans (1885). *Epimeron* Kolbe (1889), Crampton (1909). *Anopleure* Verhoeff (1903).

*Episternal paraptera* (*P*, *1P*, *2P*).—Two small pleural plates between the episternum and the base of the wing, and before the pleural wing process. The large pronator muscle of the wing is inserted upon the inner faces of both of them, upon the inner face of one only, or upon a large chitinous disk carried by either one. Frequently one is absent or rudimentary; only rarely are both absent, except in wingless species. In the Coleoptera only one epimeral paraterum is present, and in the metathorax, except in the lowest families, this one is fused with the anterior edge of the episternum and sends dorsally a long arm in front of the pleural wing process similar in appearance to the latter. The epimeral paraptera are connected with the humeral angle of the wing, especially with the head of the costa, by tough membrane, so that a contraction of the pronator muscle turns the wing forward upon



the pleural wing process and at the same time depresses its costal edge. (Also called *preparaptera*.) *Écaille axillaire* Chabrier (1820). *Hypoptère* and *paraptère* Audouin (1824). *Appareil de pronation* Amans (1885). *Alarpleure* Verhoeff (1903). *Episternalgelenkplatten* Voss (1905). *Prefulero* Berlese (1906). *First and second parapterum* Snodgrass (1908).

*Episternum* (*Eps*).—The principal pleural plate lying before or below the pleural suture and pleural ridge, in general forming the anterior half of the pleurum. *Episternum* Audouin (1824), Kolbe (1889), Crampton (1909). Anterior plate of *scapularia* in mesothorax, of *parapleura* in metathorax, Kirby and Spence (1826). *Première iliaque* in mesothorax, *première ischion* in metathorax, Straus-Dürckheim (1828). *Antepleuron* Amans (1885). *Coropleure* Verhoeff (1903).

*Femur* (*F*).—The third segment of the leg. *Femur* Fabricius (1778). *Humerus* in prothorax, *femur* in meso- and metathorax, Kirby and Spence (1826). *Cuisse* Straus-Dürckheim (1828).

*First axillary* (1, 1.1*a*, *transverse shading*).—The first articular sclerite of the wing base, hinging upon the anterior notal wing process, and specially connected with the base of the subcostal vein of the wing. In rare cases it is divided into two. *Grand humeral* of front wing, *scutellaire* of hind wing, Jurine (1820). *Humerus* Chabrier (1820). *Preepaulière* of elytrum, *axillaire antérieure* of hind wing, Straus-Dürckheim (1828). *Parapteron* Newport (1839). *Sigmoïde* Amans (1885), Petri (1899). *Dens* Lowne (1892). *Vordere* and *mittlere Tergalplatten* Voss (1905). First sclerite of *proptero* Berlese (1906).

*Fourth axillary* (4, 4.1*a*, *transverse shading*).—The fourth articular sclerite of the wing base, articulating with the posterior notal wing process mesially and with the third axillary distally. Usually this sclerite is absent, occurring principally in Orthoptera and Hymenoptera. *Naviculaire* Jurine (1820). *Hintere tergalplatte* Voss (1905). Not the *quatrième axillaire* of Straus-Dürckheim (1828).

*Frenulum* (*Fr*).—A strong spine or bunch of bristles borne by the humeral angle of the hind wing on the base of the costa (201) in most Lepidoptera. By catching in a hook on the under surface of the fore wing it serves to lock the two together. It is absent in those forms provided with a jugum. *Tendo* Kirby and Spence (1826).

*Furca* (*Fe*).—The biramous apodemes of the thoracic sterna. Sometimes the two arms have separate bases. They are usually attached by short muscles or ligaments to the arms of the pleural ridges. (See *entosternum*.) *Entosternum* Chabrier (1820), Amans (1885). *Entothorax* Audouin (1824). *Antefurca*, *medifurca*, and *postfurca* Kirby and Spence (1826). *Episternae* Straus-Dürckheim (1828). *Apophysen* Kolbe (1889), Voss (1905).



*Gonapophyses* (*Gon.*)—The chitinous processes of the eighth and ninth abdominal sterna which form the ovipositor or sting. Two arise from the eighth segment and four from the ninth. *Gonapophyses* Huxley (1878).

*Gula* (*Gu.*)—The throat region, specifically a plate forming the posterior part of the floor of the head in Neuroptera and Coleoptera, bridging the space between the genæ and supporting the labium. Probably derived from the sternum of the microthorax. *Jugulum* and *gula* Kirby and Spence (1826). *Pièce basilaire* Straus-Dürckheim (1828), Lacordaire (1834). *Gula* Newport (1839).

*Halter* (*Hl.*)—The balancer-like representative of the wing in the metathorax of Diptera. It is wing like in pupæ of Tipulidæ (173, W<sub>3</sub>). *Halter* Fabricius (1778).

*Head* (*H.*)—Formed of the first five or six embryonic metameres consolidated, with the fused appendages of the next or microthoracic segment attached and forming the labium.

*Intersegmental membrane* (*Mb.*)—The membranous area between two segments. Where phragmæ are present the membrane extends from the dorsal edge of the posterior lamella of the preceding phragma to the dorsal edge of the anterior lamella of the following phragma.

*Jugum* (*Ju.*)—The lobe at the base of the fore wing in the lower Lepidoptera serving to lock the wings together during flight. The jugum is strengthened by the third anal vein (202) and is, hence, not homologous with the alula of Diptera and Coleoptera. *Pterygium* Kirby and Spence (1826).

*Katopleure* (*Peps.*)—See *Preepisternum*.

*Lateral notal emargination* (*Em.*)—A deep notch on the lateral edges of the meso- and metanota between the notal wing processes.

*Media* (*M.*)—The fourth principal vein of the wing.

*Median notal groove* (*G.*)—The longitudinal median groove of the metanotum in Euplexoptera and Coleoptera. *Goutière médiane* Straus-Dürckheim (1828).

*Median plates of the wing base* (*m.*)—The variable plates in the median region of the base of the wing, associated with the bases of the median and cubital veins. *Rétro-médian* Amans (1885). *Vermittelungsplatte* and *vordere Analgelenkplatte* Voss (1905).

*Median segment* (*IT.*)—The "segment médiane" of Latreille (1821), or the first abdominal segment in Hymenoptera, which is transferred to the thorax and solidly fused with it. It always bears the first abdominal spiracles. *Segment médiane* Latreille (1821). *Propodeon* Newman (1833).

*Mesothorax* (*Mes.*)—The second thoracic segment. *Segmentaire antérieur* Chabrier (1820). *Mesothorax* Audouin (1824). *First segment of alitruncus* Kirby and Spence (1826). *Prothorax* Straus-Dürckheim (1828).

*Metamere*.—Any one of the primitive segments of an embryo.

*Metathorax* (*Met*).—The third thoracic segment. It is sometimes confused with the first abdominal segment in Diptera, and has this segment incorporated into it in the Hymenoptera. *Segment alaire posterior* Chabrier (1820). *Metathorax* Audouin (1824), Straus-Dürckheim (1828). *Second segment of alitruncus* Kirby and Spence (1826).

*Microthorax* (*Mi*).—The body of the neck segment. Its sclerites form the cervical sclerites of the neck and probably the gular plate of the head. Its appendages are transferred to the head and fuse to form the labium. *Microthorax* Verhoell (1902). *Collo* Berlese (1906). *Cervicum* Crampton (1909).

*Muscle disk* (*MD*).—Any disk-like or cup-shaped apodeme, usually stalked, forming the attachment or insertion of a muscle.

*Notal wing processes* (*NP, PNP*).—The anterior and posterior lateral processes of the notum to which are articulated the first and fourth axillaries, or first and third when the fourth is absent. (See *Anterior notal wing process* and *Posterior notal wing process*.)

*Notum* (*N*).—This term is restricted in this paper to the anterior or wing-bearing plate of the tergum in the meso- and metathorax, the name *postnotum* or *pseudonotum* being given to the secondary posterior plate of the back. Where the latter is absent, as it is in all the other body segments and in all the segments of nymphs and of adult Orthoptera, the notum is the entire tergum.

*Paraptera* (*P, 1 P, 2 P, 3 P, 4 P*).—The small pleural plates at the base of the wing, typically two before the pleural wing process and two behind it. The former are the *preparaptera* or *episternal paraptera* (which see); the latter are the *postparaptera* or *epimeral paraptera* (which see). *Paraptère* Audouin (1824). *Pleural gelenkplatten* Voss (1905).

*Patagium*.—The patagia are two vertically elevated lobes of the pronotum in many Lepidoptera. They vary from thick swellings to flat plates. They should not be confused with the tegulae of the mesothorax, which are also highly developed in the Lepidoptera. *Patagium* Kirby and Spence (1826).

*Pectus*.—A term used by the earlier entomologists to designate the ventral and pleural surfaces together of any thoracic segment. *Pectus* Fabricius (1778), Audouin (1824), Kirby and Spence (1826). *Conque pectorale* Chabrier (1820).

*Pérित्रème* (*Pt*).—The small plate sometimes surrounding a spiracle. *Pérित्रème* Audouin (1824).

*Phragma* (*Ph*).—The vertical or oblique plate depending from the anterior or posterior edge of any tergum. A phragma is really a chitinized inflexion of the intersegmental membrane and, hence, is always composed of two lamellae, though these are closely appressed

or fused into one plate. An anterior phragma on any segment is a *prephragma* (*Aph*) and a posterior phragma a *postphragma* (*Pph*). A tergum may be provided with both, but the postphragma is nearly always the larger. When a pseudonotum is present it carries the postphragma. (See *Prephragma* and *Postphragma*.) *Phragma* Kirby and Spence (1826), Packard (1898).

*Pleural arm* (*PA*).—The arm of the pleural ridge present in some form in most insects and usually connected with the corresponding arm of the sternal furca of the same segment. *Apodemzinken* Voss (1905). *Processo pleurale* Berlese (1906). *Adfurcal process* Crampton (1909).

*Pleural coxal process* (*CxP*).—The condyle at the lower end of the pleural ridge to which the coxa is articulated. Absent in only a few cases, though often hidden by overlapping extensions of the pleurites. *Apophyse pedio-pleurale* Amans (1888). *Coxalgelenkkopf* Voss (1905). *Condilo pedifero* Berlese (1906). *Coxal process* Snodgrass (1908), Crampton (1909).

*Pleural ridge* (*PR*).—The internal ridge developed along the pleural suture between the episternum and epimerum. Dorsally it forms the *pleural wing process* (*WP*) and ventrally the *pleural coxal process* (*CxP*). Internally it carries the *pleural arm* (*PA*). All of these parts together may be regarded as constituting the *entopleurum*. *Entopleuron* Amans (1885), Crampton (1909). *Pleuralleiste* Voss (1905). *Apodem* Kolbe (1889). *Pleurale* Berlese (1906).

*Pleural suture* (*PS*).—The external suture between the episternum and epimerum, extending from the wing process to the coxal process. *Pleuralfurche* Voss (1905). *Pleural suture* Snodgrass (1908), Crampton (1909).

*Pleural wing process* (*WP*).—The process formed by the upper end of the pleural ridge, formed of elements derived from the episternum and epimerum, which forms the pleural support of the wing, the latter articulating with it by means of the second axillary sclerite. *L'appui de l'aile* or *clavicula thorachique* Chabrier (1820). *Alifère* Straus-Dürkheim (1828). *Clavicula alæ* Lendenfeld (1881). *Apophyse alifère* and *pivot fixe* or *médian* Amans (1885). *Ascending process* Lowne (1892). *Pleuralgelenkkopf* Voss (1905). *Fulero alifero* Berlese (1906). *Alar process* Crampton (1909).

*Pleurites* (*Eps*, *Epm*, *Peps*, *P*, *Tn*).—The sclerites constituting any pleurum. (Frequently used as synonymous with *pleura*.)

*Pleurum* (*Pl*).—The morphological lateral surface of any segment—the chitinous area on the side between the tergum and sternum. *Clavicules antérieures* in mesothorax, *plaques fulcræles* in metathorax Chabrier (1820). *Pleura* Audouin (1824). *Pleuron* Amans (1885), Crampton (1909). *Pleurum* Comstock and Kellogg (1902).



*Posterior notal ridge (PNR).*—The posterior marginal thickening of the notum, generally turned downward and forward in adult insects so that it comes to lie in front of the resulting posterior edge, the latter thus often forming a large posterior reduplication.

*Posterior notal wing process (PNP).*—The posterior lateral process on each side of the notum which articulates with the wing by the fourth axillary or by the third when the fourth is absent. It is sometimes a long arm, and in a few cases is absent as a distinct process. *Apophyse styloïde* Chabrier (1820). *Apophyse de quatrième axillaire* Straus-Dürckheim (1828). *Great alar apophysis* Lowne (1892). *Mesocondilo* Berlese (1906).

*Posterior phragma (Pph).*—See *Postphragma*.

*Posterior reduplication of the notum (Rd).*—The posterior edge of the notum folded downward and forward upon itself, leaving a free margin overlapping the succeeding parts. Often very large, as in the prothorax of Acridiidae and mesothorax of Hemiptera.

*Postnotum (PN).*—See *Pseudonotum*.

*Postparaptera (3P, 4P).*—See *Epimeral paraptera*.

*Postphragma (Pph).*—The posterior phragma of any segment. Specially developed in the meso- and metatergum, where it is carried by the pseudonotum. It is developed to the greatest extent in the mesothorax of the Diptera, where it forms the partition separating the thoracic cavity from the abdominal. (See *Phragma*.) Internal part of the *costal* of Chabrier (1820). *Phragma* of prothorax, *metaphragma* of metathorax, Kirby and Spence (1826). *Postscutellum internal* Mac Leay (1830). Internal part of *subpostdorsum* of Amans (1885). Internal part of *phragma* of Kolbe (1889). *Metaphragma* and, in some cases, *mesophragma* Berlese (1906).

*Postscutellum (PN).*—See *Pseudonotum*.

*Poststernellum (Psl).*—The fourth division of the sternum, if four parts ever occur. *Poststernum* (apparently intended for *poststernellum*) Mac Leay (1830). *Poststernellum* Comstock and Kochi (1902).

*Preepisternum (Peps).*—A pleural plate of some lower insects, especially the Orthoptera and Euplexoptera, lying before the episternum, or below it when the pleural suture is horizontal. *Katopleure* (except in Blattidae) Verhoeff (1903), Snodgrass (1908). *Episternal laterale* Crampton (1909).

*Preparaptera (P, 1P, 2P).*—See *Episternal paraptera*.

*Prephragma (Aph).*—The anterior phragma of any tergum, carried by the anterior notal ridge. *Prædorum* or *cloison cervicale* Chabrier (1820). *Prophragma* of mesothorax, *mesophragma* of metathorax, Kirby and Spence (1826). *Limbe de l'ecusson* in mesothorax, *diaphragme* in metathorax, Straus-Dürckheim (1828). *Præ-*



*cutum internal* Mac Leay (1830). Internal part of *antedorsum* of Amans (1885). *Proterophragma* in mesothorax, *deutophragma* in metathorax, Voss (1905). *Prophragma* in mesothorax, *mesophragma* in some cases in metathorax, Berlese (1906).

*Prescutum* (*Psc*).—The first subdivision of the notum. Not homologous in all orders. *Prescutum* Andouin (1824), Mac Leay (1830), Newport (1839), Kolbe (1889), Voss (1905), Crampton (1909). Exposed part of *prophragma* Kirby and Spence (1826). Exposed part of *antedorsum* Amans (1885). *Protergite* Berlese (1906).

*Presternum* (*Ps*).—The anterior division of the sternum. Sometimes it is a transverse plate, but it is frequently reduced to two small sclerites lying before the sternum proper or at the anterior angles of it. *Præsternum* Mac Leay (1830), Comstock and Kochi (1902). *Antésternum* Amans (1885). *Vorplatte* Verhoeff (1903). *Coxosternum* Börner (1904), Voss (1905). *Acrosternite* Berlese (1906). *Accessory sternal plates* Snodgrass (1908). *Præsternum* and *Sternal laterale* Crampton (1909).

*Pronator disk* (*PD*).—The large disk often carried internally by one of the episternal paraptera for the insertion of the pronator muscle. In a few cases it is attached to the adjacent part of the episternum. *Cupule du muscle pectorali-axillaire* Chabrier (1820). *Grand cupule de l'aile* Straus-Dürckheim (1828). *Grand cupule* (of pronator apparatus) Amans (1885). *Cupula* also *processo pleurale* (the second a mistaken identification with pleural arm) Berles (1906).

*Pronator muscle*.—The large muscle inserted upon the pronator disk of the preparaptera. *Muscle pectorale-axillaire* Chabrier (1820).

*Prothorax* (*Pro*).—The first segment of the thorax back of the microthoracic or neck segment. *Prothorax* Chabrier (1820), Audouin (1824). *Manitruncus* Kirby and Spence (1826). *Corselet* Straus-Dürckheim (1828).

*Pseudonotum* (*PN*).—The *postnotum*, or second tergal plate of the meso- and metathorax of nearly all adult insects except the Orthoptera, the *notum* constituting the first or wing-bearing plate of the tergum. The pseudonotum is a secondary plate, being absent in all nymphs and in the pupæ of Neuroptera and Coleoptera at least. Best developed in the higher orders and nearly always connected laterally with the epimera. It carries the postphragma. *Cloison costale* or simply *costal* Chabrier (1820). *Postscutellum* Andouin (1824), Newport (1839), Kolbe (1889), Crampton (1909). *Postfrænum* (?) in metathorax, Kirby and Spence (1826). *Tergum* in metathorax, Straus-Dürckheim (1828). *Subpostdorsum*, including postphragma, Amans (1885). *Metaphragma*, including true postphragma, Kolbe (1889). *Pseudonotum* (in Dermaptera) Verhoeff

(1903), (as a general term) Snodgrass (1908). *Acrotergite* of following tergum, in most cases, Berlese (1906).

*Radius (R)*.—The third principal vein of the wing, associated at its base with the second axillary.

*Sclerite*.—Any one of the chitinous plates of the body wall or of the appendages.

*Scutellum (Sc)*.—The third division of the notum, often forming a prominent shield-shaped or triangular elevation. Not homologous in all orders. *Scutellum* (the raised part of dorsum between wings) Fabricius (1778). *Postdorsum* or *podorsum* Chabrier (1820), Amans (1885). *Scutellum* Audouin (1824), Newport (1839), Kolbe (1889), Crampton (1909). *Scutellum* (median) and *frænum* (lateral) in mesothorax, *postscutellum* in metathorax, Kirby and Spence (1826). *Postscutum* Voss (1905). *Metatergite* Berlese (1906).

*Scutum (Sc)*.—The second division of the notum. Not homologous in all orders. *Écusson* and *dorsum* Chabrier (1820). *Scutum* Audouin (1824) Mac Leay (1830), Newport (1839), Kolbe (1889), Voss (1905), Crampton (1909). *Dorsolum* in mesothorax, *postdorsolum* in metathorax, Kirby and Spence (1826). *Dorsum* Amans (1885). *Mesotergite* Berlese (1906).

*Second axillary (2, 2 Ax, oblique shading in unbroken lines)*.—The pivotal sclerite of the wing base, resting upon the pleural wing process, articulating with the first axillary mesially and usually with the base of the radius distally. *Petit humeral* in front wing, *diadémal* in hind wing, Jurine (1820). *Omoplate* Chabrier (1820). *Epaulière antérieure* of elytron, *seconde axillaire* of hind wing, Straus-Dürckheim (1828). *Submédiæ* Amans (1885), Petri (1899). *Unguiculus* Lowne (1892). *Mittlegelenkplatte* Voss (1905). Posterior sclerite of *proptero* Berlese (1906).

*Segment*.—Any one of the divisions of the head and body corresponding with the primitive metameres. The head is a combination of segments. Also any one of the joints of the legs or antennæ.

*Segment médiaire (IT in Hymenoptera)*.—See *Median segment*.

*Spiracle (Sp)*.—Any one of the breathing apertures of the tracheal system, situated, in adult insects, along the sides of the body. In the thorax there are two on each side, one in the membrane between the pro- and the mesothorax and the other between the meso- and the metathorax. The first is commonly regarded as prothoracic and the second as metathoracic. But Börner (1903) regards the first as mesothoracic and the second as metathoracic, because, as he says, it is a well-known fact that the spiracles are developed in front of the sclerites of the segments to which they belong. In *Japyx solifugus* there are apparently four pairs of thoracic spiracles, but Börner regards the second two as being abdominal spiracles moved forward. *Stigma* Audouin (1824), Newport (1839). *Spiracle* Kirby and Spence (1826).

*Sternellum* (*Sl*).—The third division of the sternum. *Sternellum* MacLeay (1830), Comstock and Kochi 1902. *Poststernum* Amans (1885).

*Sternites* (*Ps, S, Sl*).—All the sclerites of any sternum. (Generally used as synonymous with *sterna*.)

*Sternum* (*S*).—The entire ventral surface of any segment corresponding with the *tergum*, or also, specifically, the principal or second sternal sclerite. *Sternum* Audouin (1824).

*Subcosta* (*Sc*).—The second principal vein of the wing, associated at its base with the first axillary.

*Supracpimerum*.—A dorsal subdivision of the epimerum in the meso- and metathorax of Coleoptera (*epm*), often entirely separated in the metathorax. *Parapleure* Kolbe (1889), *Postparapterum* Snodgrass (1908).

*Tarsus*.—The foot of insects, composed of five, or fewer, small joints, the last bearing the claws. *Tarsus* Fabricius (1778) *Manus* of front leg, *tarsus* of middle and hind legs, Kirby and Spence (1826).

*Tegula* (*Tg*).—The scale-like plate overlapping the front angle of the base of the wing in Lepidoptera, Hymenoptera, and Diptera, and its pad-like representative at the base of the wing in other orders. The tegulae of the front wings of Lepidoptera are specially large and are carried by special *tegular plates* (*tg*) of the notum. These, in turn, are supported by special internal *tegular arms* (*tg A*) from the bases of the pleural wing processes. *Cuilleron* Jurine (1820). *Tegula* Kirby and Spence (1826). *Parapteron* MacLeay (1830).

*Tergites* (*Psc, Sct, Scl, PN*).—The sclerites composing the tergum of any segment. (Generally used as synonymous with *terga*.)

*Tergum* (*T*).—The entire chitinization of the dorsum of any segment. (See *Notum* and *Pseudonotum*.) *Tergum* Audouin (1824), MacLeay (1830). *Notum* Burmeister (1832), Newport (1839). *Prothorax*, *mesothorax* and *metathorax* (thoracic terga) Kirby and Spence (1826). *Bouchier* (protergum), *écusson* (mesotergum), *clypeus* and *tergum* (metatergum) Straus-Dürckheim (1828).

*Third axillary* (*3, 3 Ax, longitudinal shading*).—The sclerite of the wing base associated with the bases of the anal veins and affording insertion for the muscles which fold the anal area of the wing. Anteriorly it articulates with a process of the second axillary, and mesally with the posterior notal wing process except when the fourth axillary is present, which intervenes between the third and the wing process. The muscle insertion is on the mesal side of the axis of the sclerite so that by its contraction the sclerite revolves and folds the attached anal part of the wing. *Petit cubital* of front wing, *fourchu* of hind wing, Jurine (1820). *Onguiculus* Chabrier (1820). *Epaulière postérieure* of elytrum, *quatrième axillaire* of hind wing, Straus-Dürckheim (1828). *Terminal* Amans (1885), Petri (1899). *Meta-*



*pterygium* and *deltoid* Lowne (1902). *Analwurzelplatte* and *hintere Analgelenkplatte* Voss (1905). *Mesoptero* Berlese (1906).

*Thorax*.—The middle division of an insect, composed of three segments—the *prothorax*, the *mesothorax*, and the *metathorax*. The microthorax is the segment of the neck sclerites and the labium, and there is, hence, no reason for counting it as a thoracic segment. The primitive thoracic region may have been composed of a greater number of segments than three, but the extra ones have disappeared or remained only as small intersegmental plates in some of the Aptera. *Truncus* Fabricius (1778), Kirby and Spence (1826). *Thorax* Chabrier (1820), Audouin (1824), *Corselet* (prothorax) and *thorax* (meso- and metathorax) Straus-Dürckheim (1828).

*Tibia* (*Tb*).—The fourth joint of the leg, between the femur and the tarsus. *Tibia* Fabricius (1778). *Cubitus* of front leg, *tibia* of middle and hind legs, Kirby and Spence (1826). *Jambe* Straus-Dürckheim (1828).

*Trochanter* (*Tr*).—The second joint of the leg, between the coxa and the femur. It consists of two subjoints in some Hymenoptera. *Scapula* of front leg, *trochanter* of middle and hind legs, Kirby and Spence (1826). *Trochanter* Straus-Dürckheim (1828).

*Trochantin* (*Tn*).—The plate of the thoracic wall anterior to the base of the leg, articulating above with the episternum and below with the ventral rim of the coxa. It is large and prominent in most of the lower insects, but is frequently absent or fused with the sternum or episternum in the higher orders. It is situated on the side of the thorax, but may be a sternal plate in its origin. The coxa is normally articulated above to the coxal process (*CxP*) of the pleurum, and below to the coxal process of the trochantin (*TnC*). Only in rare cases is it articulated to the sternum, as in the nymphs of Odonata. *Trochantin* Audouin (1824), Verhoeff (1903), Snodgrass (1908), Crampton (1909). *Rotule* Straus-Dürckheim (1828). *Trochantinus* Kolbe (1889). Not the *trochantine* of Packard (1898). *First antecoxal piece* (Blattidæ) Comstock and Kochi (1902). *Præcoxalplatte* (*Trochantin*) Voss (1905). *Trochantino* Berlese (1906).

*Vena dividens* (*D*).—The secondary vein developed in the first anal fold of the wing of some insects, especially in Orthoptera.

*Venter*.—The entire morphological ventral surface of the insect or of any part or segment, corresponding with the *dorsum* above. The *sterna* are the segmental chitinizations of the venter, and the *sternites* (as used in this paper) the sclerites of any sternum.

*Wings* (*W<sub>2</sub>*, *W<sub>3</sub>*).—The organs of flight. In the nymphs of insects with incomplete metamorphosis the wings appear to be extensions of the lateral edges of the meso- and metathoracic terga. In adults they



appear to be outgrowths of the body wall from the tergo-pleural sutures, and are articulated to the wing processes of the tergum and pleurum by the *axillary sclerites*.

*Wing Process (WP).*— See *Pleural wing process*.

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## X. EXPLANATION OF THE PLATES.

(Drawings by the writer.)

### Abbreviations.

- A*, anal vein or veins.  
*AF*, anal fold of the wing.  
*Al*, alula.  
*ANP*, anterior notal wing process.  
*ANR*, anterior notal ridge.  
*anr*, line on surface of notum formed by ANR.  
*Ap*, apodeme.  
*Aph*, anterior phragma or prephragma in each segment.  
*Au*, auditory organ of locust.  
*1Ax*, *2Ax*, *3Ax*, *4Ax* (also *1*, *2*, *3*, *4*), the first, second, third, and fourth axillaries or articular sclerites of the wing base. On plates 64-69 the first and fourth indicated by transverse shading, the second by oblique, the third by longitudinal.  
*AxC*, axillary cord.  
*AxM*, axillary membrane.  
*C*, costa or first vein of wing.  
*Cr*, cercus, appendage of tenth abdominal segment.  
*Cu*, cubitus, or fifth vein of wing.  
*Cx*, coxa.  
*Cxa*, accessory sclerite at base of coxa.  
*CxC*, coxal cavity.  
*CxP*, coxal process.  
*D*, vena dividens.  
*El*, elytrum.  
*Em*, lateral emargination of notum.  
*Epm*, epimerum.  
*epm*, subdivision of epimerum.  
*Eps*, episternum.  
*eps*, subdivision of episternum.  
*F*, femur.



- Fc*, furca or entosternum.  
*Fr*, frenulum.  
*G*, median groove of notum.  
*Gu*, gula.  
*H*, head, or base of head.  
*Hl*, halter.  
*IPh*, phragma of first abdominal tergum.  
*IS-XS*, first to tenth abdominal sterna.  
*ISp*, *IISp*, first and second abdominal spiracles.  
*IT-XT*, first to tenth abdominal terga.  
*Ju*, jugum.  
*M*, media or fourth vein of wing.  
*Mb*, intersegmental membrane.  
*mb*, membranous area in prescutum of Coleoptera.  
*MD*, muscle disc.  
*Mes*, mesothorax.  
*Met*, metathorax.  
*Mi*, microthorax.  
*mi*, cervical or microthoracic sclerites.  
*N*, notum.  
*NA*, notal (pseudopleural) internal arm of pronotum of *Melanoplus*.  
*NCrP*, notal (pseudopleural) coxal process of prothorax of *Melanoplus*.  
*NR*, internal notal (pseudopleural) ridge of prothorax of *Melanoplus*.  
*P*, parapterum.  
*1P*, *2P*, first and second preapaptera or episternal paraptera.  
*3P*, postapapterum or epimeral parapterum.  
*PA*, pleural arm of the internal pleural ridge.  
*PD*, parapteral or pronator muscle disc.  
*Peps*, preëpisternum.  
*Ph*, phragma.  
*Pl*, plate in pleurum of Chilopoda.  
*PN*, pseudonotum or postnotum (postscutellum).  
*PNP*, posterior notal wing process.  
*PNR*, posterior notal ridge.  
*pnr*, line on the surface of notum formed by PNR.  
*Pph*, posterior phragma or postphragma of each segment.  
*PR*, pleural ridge (pleural apodeme, entopleurum).  
*PS*, pleural suture, between episternum and epimerum forming pleural ridge (*PR*) internally.  
*Ps*, presternum, or presternal plates.  
*pse*, prescutum.  
*R*, radius or third vein of wing.  
*Rd*, posterior reduplication of edge of notum.  
*S*, sternum.  
*IS-XS*, first to tenth abdominal sterna.  
*Sc*, subcosta or second vein of wing.  
*scl*, scutellum.  
*sct*, scutum.  
*Sl*, sternellum.  
*Sm*, submentum.  
*Sp*, spiracle.  
*1 Sp*, *2 Sp*, first and second thoracic spiracles.  
*I Sp*, *II Sp*, first and second abdominal spiracles.  
*T*, tergum.

*IT-XT*, first to tenth abdominal terga.

*It*, subdivision of first abdominal tergum.

*Tg*, tegula or its rudiment.

*tg*, tegular plate of Lepidopteran notum carrying the tegula.

*tgA*, tegular arm of pleural wing process in Lepidoptera supporting tegular plate of notum.

*Tn*, trochantin.

*tn*, subdivision of trochantin.

*Tna*, accessory trochantinal plate.

*TnC*, trochantinal articulation of coxa.

*TnCtP*, trochantinal (pseudopleural) coxal process in Plecoptera.

*TnR*, trochantinal (pseudopleural) ridge in Plecoptera.

*TnS*, trochantinal (pseudopleural) suture in Plecoptera.

*V*, entodorsum or V-shaped ridge on undersurface of meso- and metathoracic nota.

*v*, V-shaped line formed on surface of notum by the entodorsum (*V*) or V-shaped ridge of undersurface.

*W*, wing.

*w*, transverse ventral ridge of metanotum in Coleoptera or its line on dorsal surface of notum dividing the scutum into two plates.

*WP*, wing process of pleurum.

#### *Miscellaneous lettering.*

*a*, postepimeral strip of pronotum in Odonata (5, 7, 12).

*b*, rod connecting prosternum and mesosternum in Odonata (6, 10, 11).

*c*, rod connecting parapterum with head of costa in Ephemerida (1, 4).

*d*, sternal coxal condyl in nymphs of Odonata (11, 16).

*e*, sternal pit or pits marking the location of the furca (10, 11).

*f*, posterior arms of the metanotum in Euplexoptera (96).

*g*, prothoracic spiracular plates in Odonata attached to mesothorax (18).

*h*, anterior arm of pleural wing process in Odonata (18, 19).

*i*, points of articulation of pseudonotum (postscutellum) in Coleoptera with epimera (132-137, 139, 140).

*j*, small plates yoking mesonotum and metanotum in *Blatella* (38, 40).

*k*, coxal condyle of epimerum in *Benacus* (84, 89).

*l*, median sternal apodeme of *Phassus* (152).

*mi*, individual plates of microthorax.

*n*, rod connecting parapterum with wing base in Euplexoptera (mesothorax 90, metathorax 98, 100).

*o*, point of insertion of posterior muscle disk of wing in *Cyllene* (140).

*p*, small sclerite in prothorax of *Phassus* (152) bearing procoxa.

*q*, yoke plates between mesonotum and metanotum in Coleoptera (127, 128, 131).

*r*, common base of anal veins fused with end of scutellum in *Dytiscus* (136, 137).

*s*, ridges on under surface of meso- and metanotum in Acridiidae (54) or lines formed by them on dorsal surface (53).

*It*, anterior subdivision of first abdominal tergum (*IT*) in Acridiidae (57).

*tg*, plate on Lepidopteran notum supporting the tegula (149, 150, 156).

*tgA*, arm of pleural wing process in Lepidoptera supporting tegular plate (*tg*) of notum (153, 154).

*tn*, subdivision of trochantin in Blattidae (32, 35).

*u*, lobe at posterior lateral angles of prescutum in Diptera (175, 180).

- v*, line on dorsal surface of notum formed by ventral V-shaped ridge, in some Orthoptera (38, 50), Coleoptera (131, 133, 137, 138), Neuroptera (143), Lepidoptera (149, 150, 151, 156), Diptera (175, 180).
- w*, transverse ridge or ridges on under surface of metanotum in Coleoptera or its line on the dorsal surface, dividing the scutum into two regions (132-138, 140).
- x, y, z*, anterior, middle, and posterior transverse external grooves and corresponding internal ridges on pronotum of *Melanoplus* (51, 52). The middle ridge (NR) takes place of pleural ridge.

#### Numbering.

- 1, 2, 3, 4, first axillary (1*Ax*), second axillary (2*Ax*), third axillary (3*Ax*), and fourth axillary (4*Ax*) of wing base.
- Roman numerals I-X designate first to tenth abdominal segments, combined with letters *T* and *S* indicate terga and sterna of individual segments.
- Figures 1, 2, and 3 placed behind and below an abbreviation refer it to the prothorax, mesothorax, or metathorax, respectively.
- Figures 1, 2, 3, etc., placed before an abbreviation signify first, second, third, etc.

#### PLATE 40.

- Fig. 1. *Hexagenia bilineata*, mesothorax and base of wing, lateral.  
 2. *Hexagenia bilineata*, metathorax and base of wing, lateral.  
 3. *Hexagenia bilineata*, metatergum.  
 4. *Hexagenia bilineata*, mesotergum and base of right wing.

#### PLATE 41.

- Fig. 5. *Libellula auripennis*, adult, prothorax and microthorax, lateral.  
 6. *Libellula auripennis*, adult, plates of microthorax (*mi*), prosternum (*S*) and presternum (*Ps*).  
 7. *Pachydiplax longipennis*, adult, prothorax, lateral.  
 8. *Lestes uncatus*, nymph, microthorax and prothorax, lateral.  
 9. *Lestes uncatus*, adult, microthorax and prothorax, lateral.  
 10. *Pachydiplax longipennis*, adult, prosternum.  
 11. *Gomphus brevis*, adult, prosternum.  
 12. *Gomphus plagiatus*, nymph, microthorax and prothorax, lateral.  
 13. *Gomphus brevis*, adult, prothorax, lateral.

#### PLATE 42.

- Fig. 14. *Gomphus plagiatus*, large nymph, meso- and metathorax, dorsal.  
 15. *Pachydiplax longipennis*, small nymph, meso- and metanotum and bases of wings.  
 16. *Libellula pulchella*, nymph, meso- and metathorax, lateral.  
 17. *Pachydiplax longipennis*, adult, meso- and metatergum and bases of right wings.  
 18. *Libellula auripennis*, adult, meso- and metapleurum, external.  
 19. *Libellula auripennis*, adult, metapleurum, internal.

#### PLATE 43.

- Fig. 20. *Mecistocephalus* sp., lateral view of a segment.  
 21. *Scolopocryptops* sp., fifteenth segment, lateral.  
 22. *Lithobius* sp., a large segment, lateral.

- Fig. 23. *Cermatia forceps*, large pleurum of tenth double segment, lateral.  
24. *Spodromantis guttata*, dorsum of microthorax.  
25. *Spodromantis guttata*, microthorax and submentum, ventral.  
26. *Spodromantis guttata*, propleurum, external.  
27. *Spodromantis guttata*, mesopleurum, external.  
28. *Spodromantis guttata*, mesopleurum, internal.  
29. *Byrsotria fumigata*, propleurum, external.  
30. *Spodromantis guttata*, mesonotum, ventral.  
31. Mantid nymph, mesonotum, ventral.

## PLATE 44.

- Fig. 32. *Byrsotria fumigata*, female, mesosternum, mesopleura and coxæ, ventral.  
33. *Byrsotria fumigata*, female, mesopleurum, internal.  
34. *Byrsotria fumigata*, male, mesopleurum, external.  
35. *Ischnoptera hyalina*, mesopleurum, external.  
36. *Ischnoptera hyalina*, microthorax, dorsal.  
37. *Ischnoptera hyalina*, microthorax, ventral.  
38. *Blatella germanica*, metanotum, dorsal.  
39. *Microcentrum laurifolium*, metanotum, ventral.  
40. *Blatella germanica*, metanotum, ventral.  
41. *Microcentrum laurifolium*, mesonotum, ventral.

## PLATE 45.

- Fig. 42. *Anabrus simplex*, mesonotum.  
43. *Anabrus simplex*, male mesopleurum, external.  
44. *Anabrus simplex*, male, mesopleurum, internal.  
45. *Gryllus pennsylvanicus*, microthorax and labium, ventral.  
46. *Gryllus pennsylvanicus*, propleurum, prosternum and coxa, anterior.  
47. *Gryllus pennsylvanicus*, mesopleurum, mesosternum and coxa, anterior.  
48. *Gryllus pennsylvanicus*, upper end of metapleurum, internal.  
49. *Gryllus pennsylvanicus*, long-winged female, metanotum, ventral.  
50. *Gryllus pennsylvanicus*, short-winged female, metanotum, dorsal.

## PLATE 46.

- Fig. 51. *Melanoplus femur-rubrum*, prothorax, external, lateral.  
52. *Melanoplus femur-rubrum*, prothorax, internal, lateral.  
53. *Hippiscus phanicopterus*, mesonotum.  
54. *Hippiscus phanicopterus*, mesonotum, ventral.  
55. *Melanoplus* nymph, meso and metapleurum, internal.  
56. *Melanoplus* nymph, meso and metathorax and first two abdominal segments, lateral.  
57. *Hippiscus phanicopterus*, metapleurum with bases of wing and leg, and first abdominal segment, lateral.

## PLATE 47.

- Fig. 58. *Melanoplus* nymph, meso- and metatergum.  
59. Mantid nymph, hind wing.  
60. Cockroach, diagram of hind wing.  
61. *Spodromantis guttata*, front wing.



- Fig. 62. *Spodromantis guttata*, hind wing.  
 63. *Microcentrum laurifolium*, front wing.  
 64. *Microcentrum laurifolium*, hind wing.

## PLATE 48.

- Fig. 65. *Gryllotalpa borealis*, hind wing.  
 66. *Gryllus pennsylvanicus*, long-winged female, hind wing.  
 67. *Gryllus pennsylvanicus*, long-winged female, front wing.  
 68. *Dissosteira carolina*, front wing.  
 69. *Dissosteira carolina*, hind wing.

## PLATE 49.

- Fig. 70. *Dissosteira carolina*, mesopleurum, external.  
 71. *Dissosteira carolina*, mesopleurum, internal.  
 72. *Pteronarcys californica*, prothorax, lateral.  
 73. *Perla* nymph, prothorax, lateral.  
 74. *Perla* nymph, propleurum, internal.  
 75. *Pteronarcys californica*, mesotergum.  
 76. *Perla* nymph, metatergum.  
 77. *Perla* nymph, metathorax, lateral.

## PLATE 50.

- Fig. 78. *Pteronarcys californica*, metapleurum, external.  
 79. *Pteronarcys californica*, metapleurum, internal.  
 80. *Isogenus* nymph, mesopleurum, external.  
 81. *Acroneuria* nymph, mesopleurum, internal.  
 82. *Cerastipsocus venosus*, meso- and metapleurum, external.  
 83. *Benacus haldemanus*, prothorax, anterior, left coxa removed from coxal cavity (*CxC*).  
 84. *Benacus haldemanus*, part of inner surface of metapleurum showing epimeral coxal condyle (*k*) and true coxal condyle (*CxP*).  
 85. *Benacus haldemanus*, mesopleurum, external.  
 86. *Benacus haldemanus*, mesopleurum, internal.

## PLATE 51.

- Fig. 87. *Benacus haldemanus*, metatergum and first abdominal tergum, dorsal.  
 88. *Benacus haldemanus*, metatergum and first abdominal tergum, posterior.  
 89. *Benacus haldemanus*, metapleurum, external.  
 90. *Spongiphora apicidentata*, mesotergum and base of right elytron.  
 91. *Spongiphora apicidentata*, propleurum, prosternum, and base of leg, ventral.  
 92. *Spongiphora apicidentata*, mesotergum, ventral.  
 93. *Spongiphora apicidentata*, microthorax and bases of head and labium, ventral.  
 94. *Spongiphora apicidentata*, mesosternum and mesopleura, ventral.  
 95. *Buprestis aurulenta*, front of prosternum, microthorax, and base of head, ventral.

## PLATE 52.

- Fig. 96. *Spongiphora brunneipennis*, metatergum and first abdominal tergum.  
 97. *Cyllene robinia*, mesopleurum, external.  
 98. *Spongiphora apicidentata*, metapleurum, half of sternum, and base of leg.  
 99. *Buprestis aurulenta*, prothoracic coxa and trochantin.  
 100. *Spongiphora apicidentata*, metapleurum, internal.  
 101. *Cyllene robinia*, mesopleurum, internal.  
 102. *Calosoma scrutator*, mesopleurum, external.  
 103. *Calosoma scrutator*, mesopleurum, internal.  
 104. *Buprestis aurulenta*, mesothoracic coxa and trochantin.

## PLATE 53.

- Fig. 105. *Hydrophilus triangularis*, mesopleurum and sternum, external.  
 106. *Silpha surinamensis*, mesopleurum, external.  
 107. *Dytiscus dauricus*, mesopleurum, external.  
 108. *Dytiscus dauricus*, mesopleurum, internal.  
 109. *Buprestis aurulenta*, mesopleurum, external.  
 110. *Calosoma scrutator*, metapleurum, internal.  
 111. *Hydrophilus triangularis*, metapleurum, external.  
 112. *Hydrophilus triangularis*, metapleurum, internal.  
 113. *Calosoma scrutator*, metapleurum, external.

## PLATE 54.

- Fig. 114. *Dytiscus dauricus*, metapleurum, external.  
 115. *Dytiscus dauricus*, metapleurum, internal.  
 116. *Cyllene robinia*, metapleurum, external.  
 117. *Melolontha vulgaris*, metapleurum, internal.  
 118. *Dendroctonus valens*, metapleurum, external.  
 119. *Cyllene robinia*, metapleurum, internal.  
 120. *Dendroctonus valens*, metapleurum, internal.  
 121. *Melolontha vulgaris*, metapleurum, external.

## PLATE 55.

- Fig. 122. *Dendroctonus valens*, pupa, meso- and metaterga with wings, and first and second abdominal terga.  
 123. *Tetropium velutinum*, pupa, meso- and metaterga with wings, and first three abdominal terga.  
 124. *Dendroctonus valens*, unemerged adult taken from pupal skin, mesotergum and base of right elytrum.  
 125. *Hydrophilus triangularis*, mesotergum.  
 126. *Dendroctonus valens*, pupa, mesotergum and bases of elytra, ventral.  
 127. *Calosoma scrutator*, mesotergum and axillaries of right elytrum.  
 128. *Dytiscus dauricus*, mesotergum and axillaries of right elytrum.  
 129. *Cyllene robinia*, mesotergum, right axillaries, right parapterum and base of elytrum.  
 130. *Cyllene robinia*, mesotergum, ventral.  
 131. *Dytiscus dauricus*, mesotergum, left axillaries and base of elytrum, ventral.

## PLATE 56.

- Fig. 132. *Calosoma scrutator*, metatergum, dorsal.  
 133. *Calosoma scrutator*, metatergum, ventral.  
 134. *Hydrophilus triangularis*, metatergum, dorsal.  
 135. *Melolontha vulgaris*, metatergum, dorsal.

## PLATE 57.

- Fig. 136. *Dytiscus dauricus*, metatergum and right axillaries, dorsal.  
 137. *Dytiscus dauricus*, metatergum, ventral.  
 138. *Melolontha vulgaris*, metanotum, ventral.  
 139. *Melolontha vulgaris*, metapseudonotum, anterior.

## PLATE 58.

- Fig. 140. *Cyllene robinia*, metatergum.  
 141. *Corydalis cornuta*, pupa, mesotergum and base of right wing.  
 142. *Corydalis cornuta*, adult, mesotergum, dorsal.  
 143. *Corydalis cornuta*, adult, metanotum, ventral (pseudonotum removed).

## PLATE 59.

- Fig. 144. *Corydalis cornuta*, larva, metathorax, lateral.  
 145. *Corydalis cornuta*, pupa, metapleurum.  
 146. Trichopteran pupa, mesopleurum.  
 147. *Corydalis cornuta*, adult, metapleurum.  
 148. *Neuronía ocellifera*, adult, mesopleurum.  
 149. *Phassus argentiferus*, thorax with wings removed, and base of abdomen, lateral.

## PLATE 60.

- Fig. 150. *Phassus argentiferus*, mesotergum and first and third axillaries with posterior part of axillary membrane of right wing.  
 151. *Phassus argentiferus*, metatergum and first abdominal tergum.  
 152. *Phassus argentiferus*, prothorax with pronotum separated, and microthoracic plates, lateral.  
 153. *Phassus triangularis*, mesopleurum and coxa, external.  
 154. *Phassus triangularis*, mesopleurum with coxa removed, internal.  
 155. *Protoparce cingulata*, prescutum and prephragma of mesonotum, anterior.  
 156. *Protoparce cingulata*, mesotergum.  
 157. *Protoparce cingulata*, metatergum.

## PLATE 61.

- Fig. 158. *Protoparce cingulata*, metapleurum.  
 159. *Protoparce cingulata*, mesopleurum.  
 160. *Parasiobla* sp. (Tenthredinidae), thorax and base of abdomen, lateral.  
 161. *Cimex americana*, mesotergum and base of right wing.  
 162. *Cimex americana*, propleurum.  
 163. *Cimex americana*, mesothorax and pronotum ( $N_1$ ), lateral.  
 164. *Cimex americana*, metathorax and first abdominal segment (median segment), lateral.

- Fig. 165. *Cimbea americana*, second parapterum of mesothorax and attached pronator muscle disk.  
166. *Cimbea americana*, abdomen except first segment, which is fused with metathorax (164), lateral.  
167. *Sirex flavipennis*, metapleurum, internal.

## PLATE 62.

- Fig. 168. *Pepsis* sp., propleurum and coxa.  
169. *Pepsis* sp., thorax except propleurum and procoxa, which are removed (168), and base of abdomen, lateral.  
170. *Pepsis* sp., mesotergum, lateral.  
171. *Sirex flavipennis*, prothorax, lateral.  
172. *Sirex flavipennis*, propleurum, internal.  
173. Tipulid pupa, head, thorax, and base of abdomen, lateral.  
174. *Holorusia grandis*, thorax, base of head, and base of abdomen, lateral.

## PLATE 63.

- Fig. 175. *Holorusia grandis*, mesotergum.  
176. *Holorusia grandis*, upper end of mesopleurum.  
177. *Holorusia grandis*, metapleurum and base of halter.  
178. *Holorusia grandis*, mesopleurum, internal.  
179. *Tabanus atratus*, thorax, lateral.  
180. *Tabanus atratus*, protergum and mesotergum.

## PLATE 64.

- Fig. 181. *Libellula auripennis*, base of front wing.  
182. *Pteronarcys californica*, base of front wing.  
183. *Pteronarcys californica*, front wing.  
184. *Pteronarcys californica*, hind wing.

## PLATE 65.

- Fig. 185. *Blatella germanica*, base of front wing.  
186. *Blatella germanica*, base of hind wing.  
187. *Dissosteira carolina*, base of front wing.  
188. *Gryllus pennsylvanicus*, base of hind wing.  
189. *Dissosteira carolina*, base of hind wing.

## PLATE 66.

- Fig. 190. *Benacus haldemanum*, base of front wing.  
191. *Benacus haldemanum*, base of hind wing.  
192. *Dytiscus dauricus*, base of wing.  
193. *Calosoma scrutator*, base of wing.  
194. *Cyllene robiniae*, base of wing.

## PLATE 67.

- Fig. 195. *Melolontha vulgaris*, base of wing.  
196. *Melolontha vulgaris*, wing.  
197. *Calosoma scrutator*, basal parts of costa, subcosta, and radius, showing detached base of costa separated, ventral.



Fig. 198. *Hydrophilus triangularis*, base of wing.

199. *Melontha vulgaris*, right axillaries separated, but in natural relative positions.

200. *Corydalis cornuta*, base of front wing.

201. *Corydalis cornuta*, base of hind wing.

PLATE 68.

Fig. 202. *Phassus argentiferus*, base of front wing and base of jugum (*Ju*).

203. *Phassus argentiferus*, base of hind wing.

204. *Protoparce cingulata*, base of hind wing with frenulum (*Fr*).

205. *Cimbex americana*, base of front wing.

206. *Sirex flavipennis*, base of front wing.

207. *Sirex flavipennis*, base of hind wing.

PLATE 69.

Fig. 208. *Pepsis*, sp., base of front wing.

209. *Pepsis* sp., base of hind wing.

210. *Holorusia grandis*, base of wing.

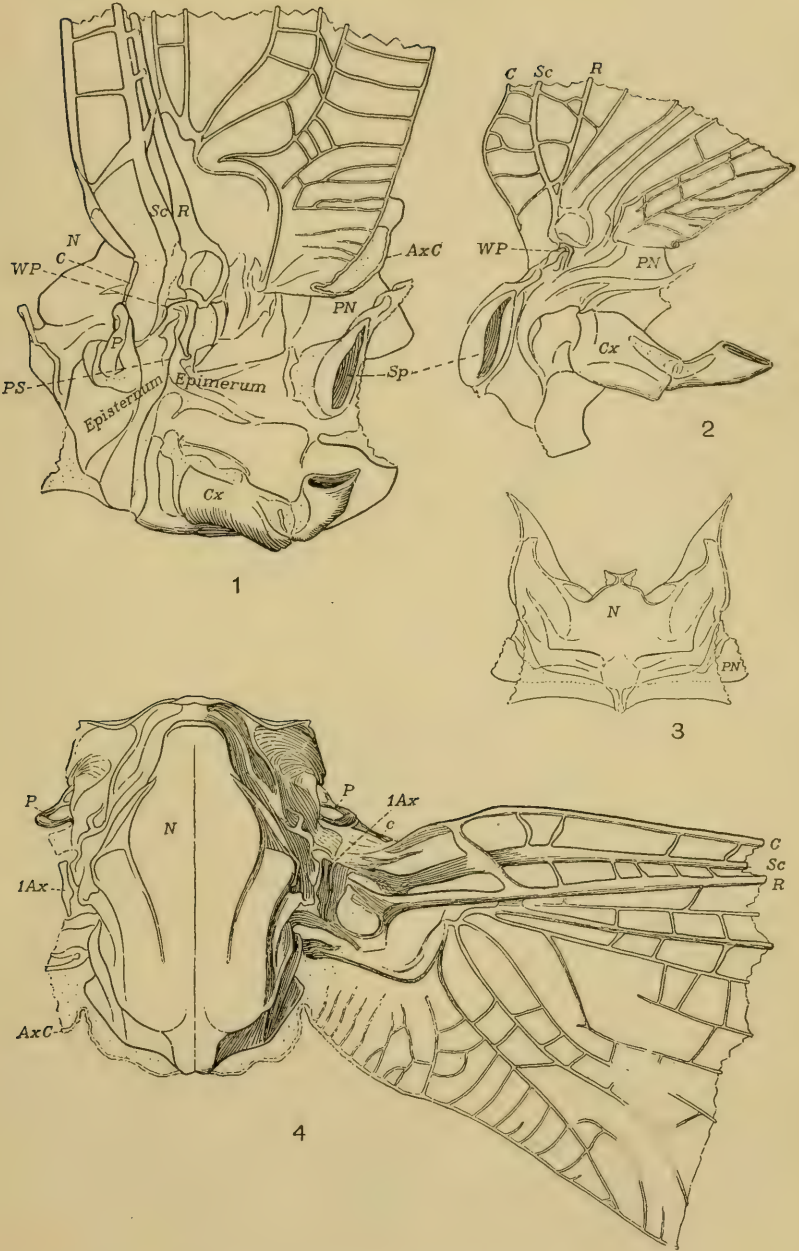
211. *Holorusia grandis*, base of halter.

212. *Calliphora vomitoria*, base of wing with the two squamæ of the alula (*Al*).

[NOTE.—Since this paper has been made up into pages the writer finds that he overlooked the fact that Riley (1904) ascribes a small part of the back of the head in *Blatta*, the "posterior maxillary pleurites" of Comstock and Kochi (1902) to the labial segment. If this is so then the microthoracic segment does play a small part in the formation of the head capsule.

As it was too late to put this in as a footnote on page 522, it has been inserted here.]



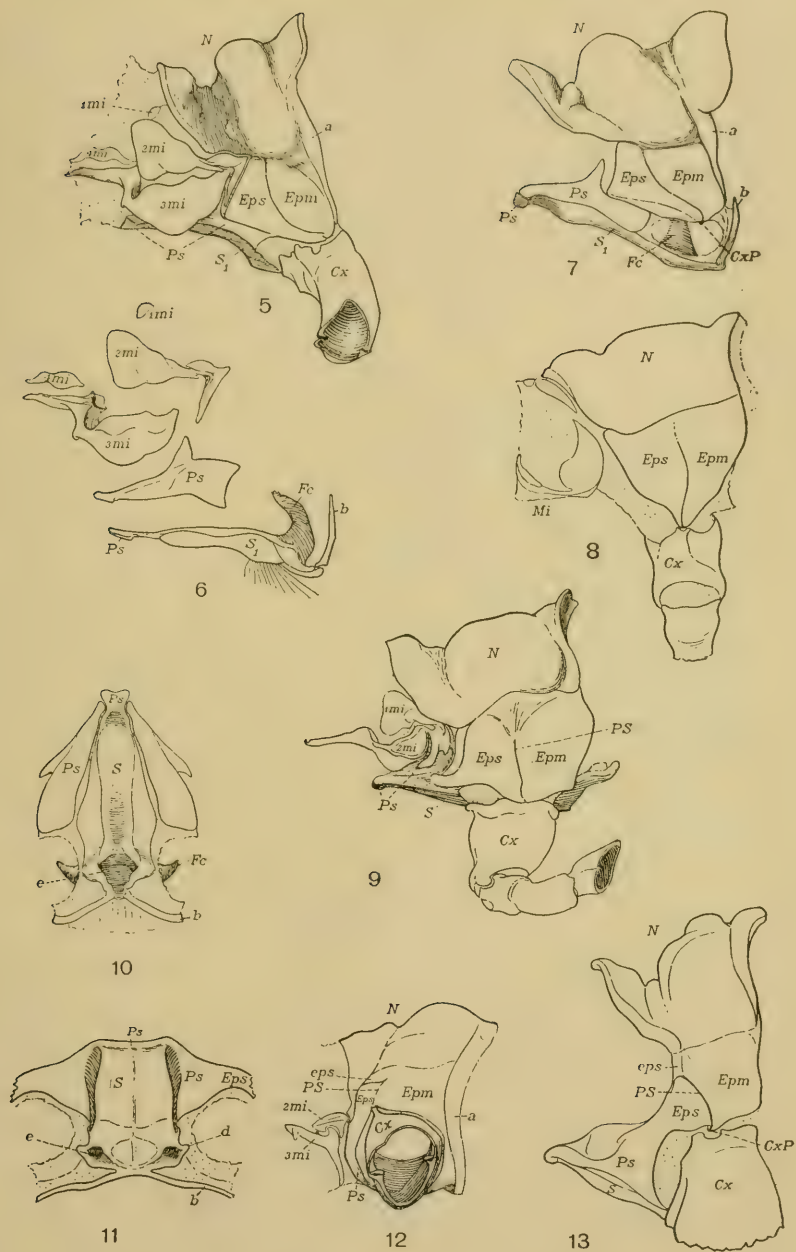


THORAX AND BASE OF WING OF MAYFLIES.

FOR EXPLANATION OF PLATE SEE PAGE 589.



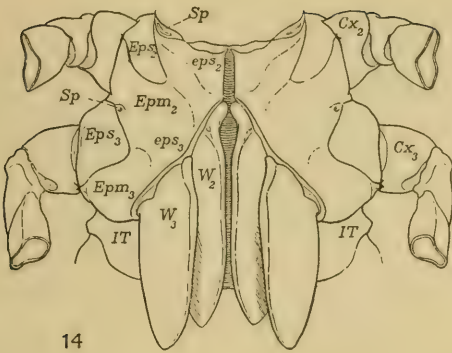




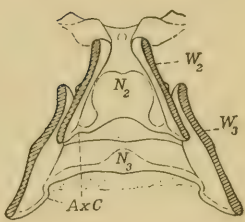
## PROTHORAX OF DRAGONFLIES.

FOR EXPLANATION OF PLATE SEE PAGE 589.

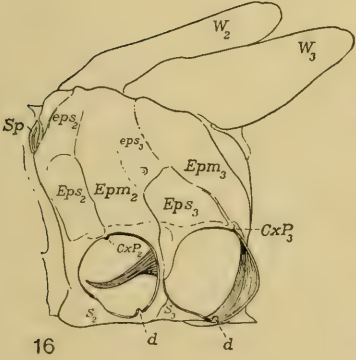




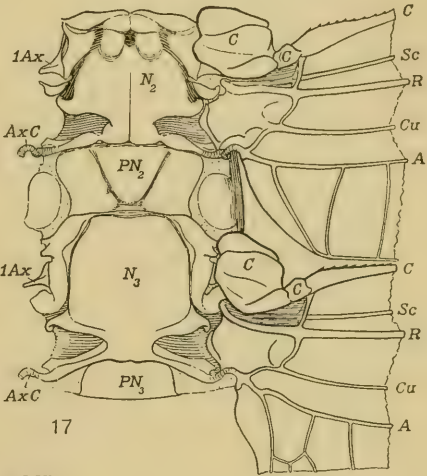
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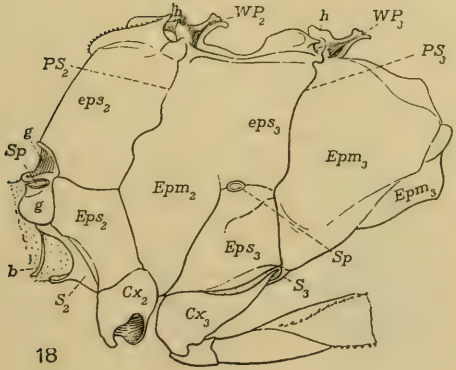
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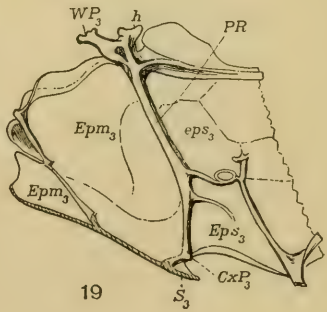
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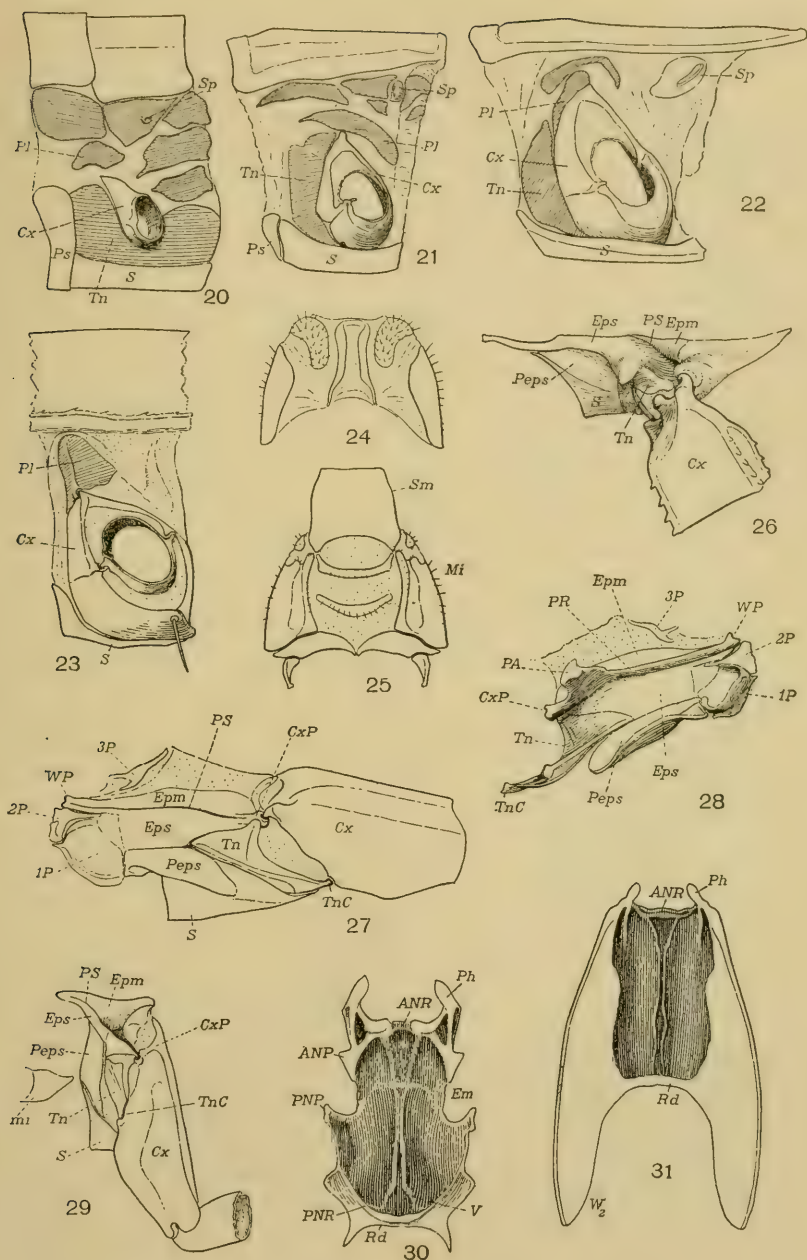
19

MESOTHORAX AND METATHORAX OF DRAGONFLIES.

FOR EXPLANATION OF PLATE SEE PAGE 589.



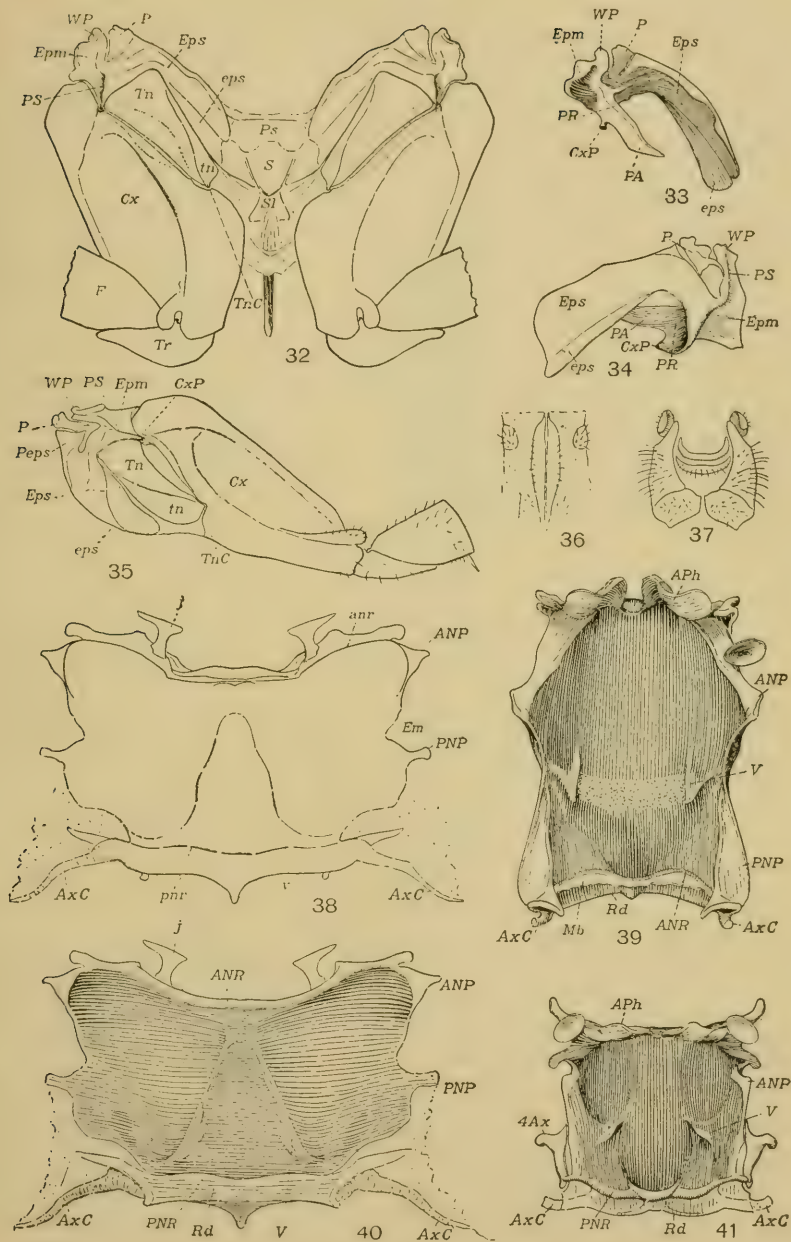




SEGMENTS OF CENTIPEDES AND THORAX OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGES 589, 590.



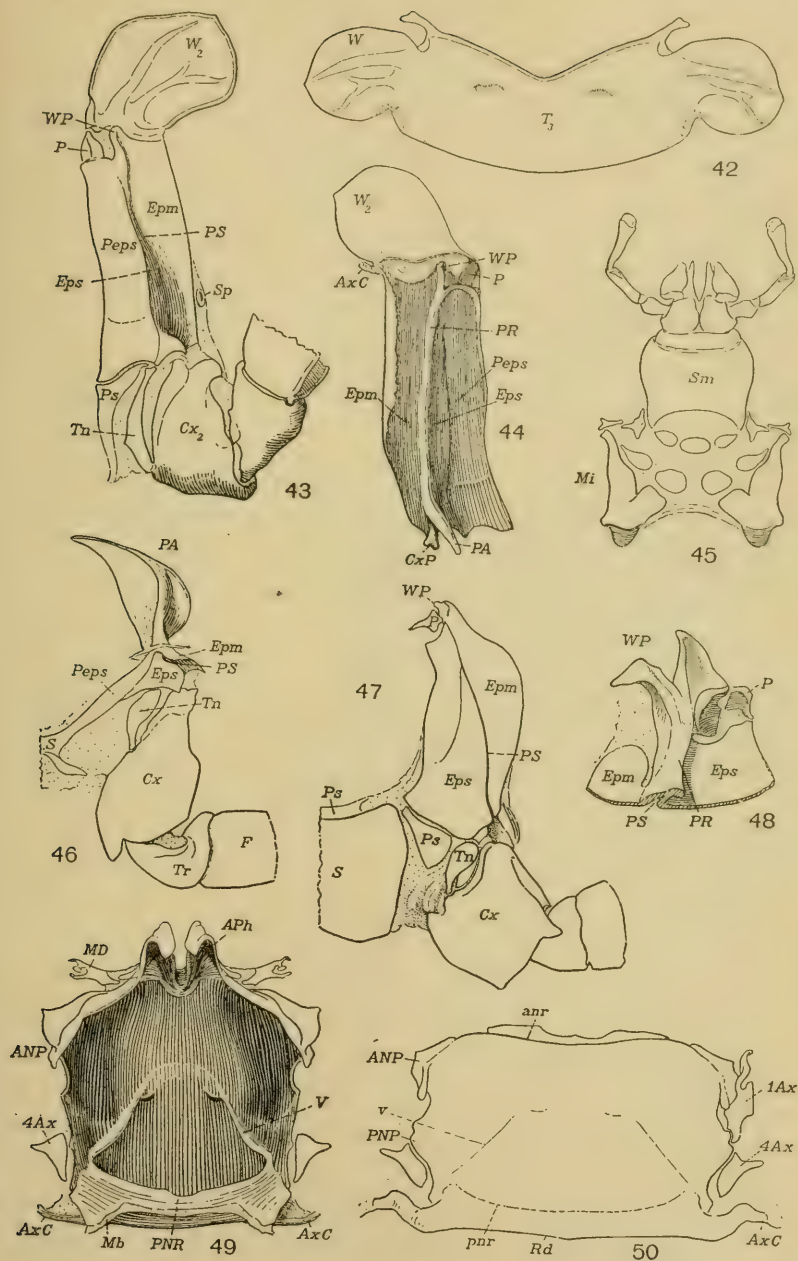


## THORAX OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 590.



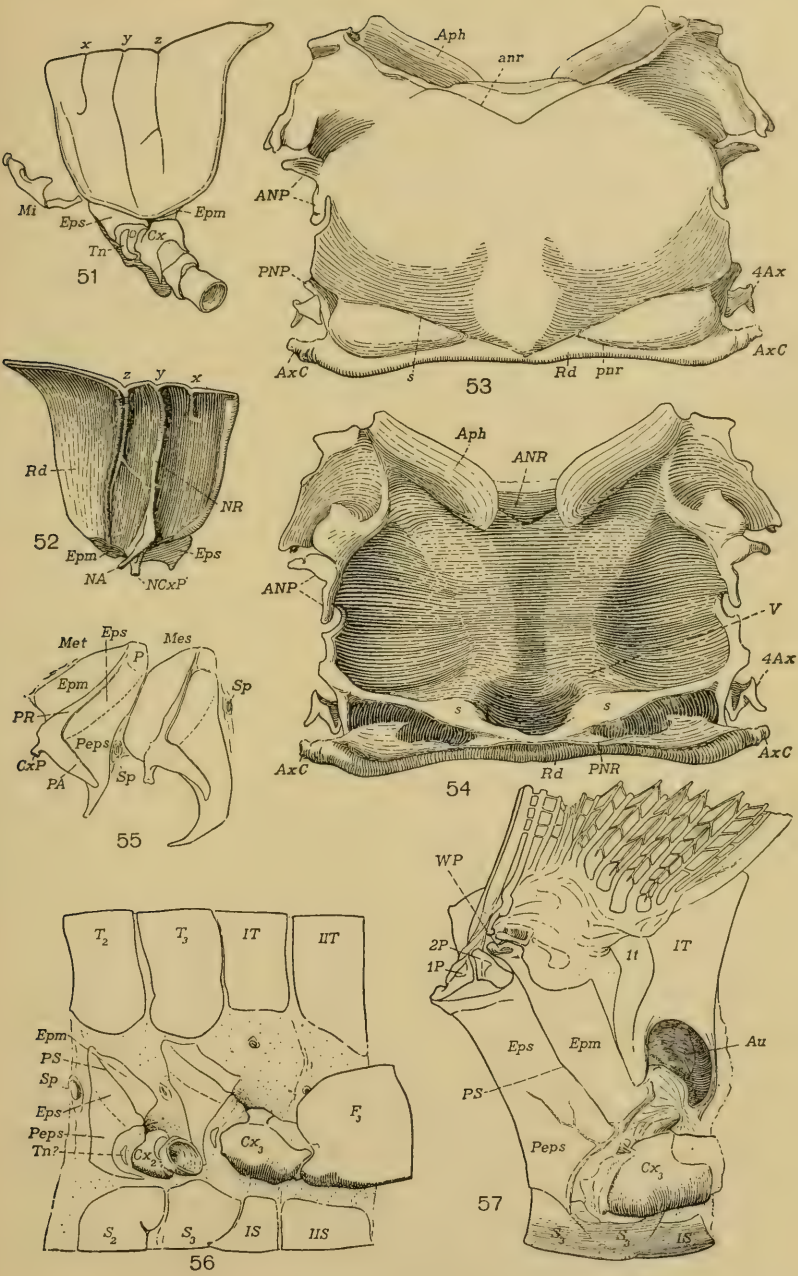




## MICROTHORAX AND THORAX OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 590.





THORAX OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 590.



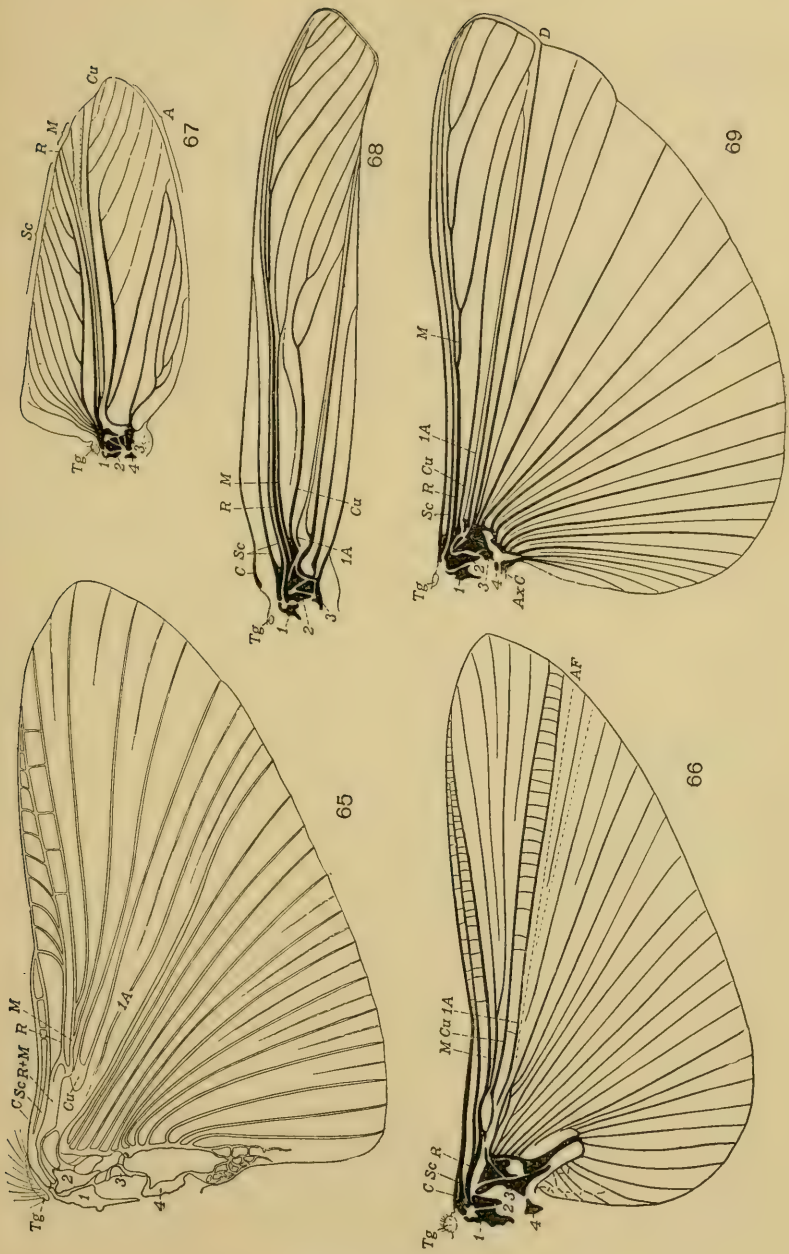




## WINGS OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGES 590-591.



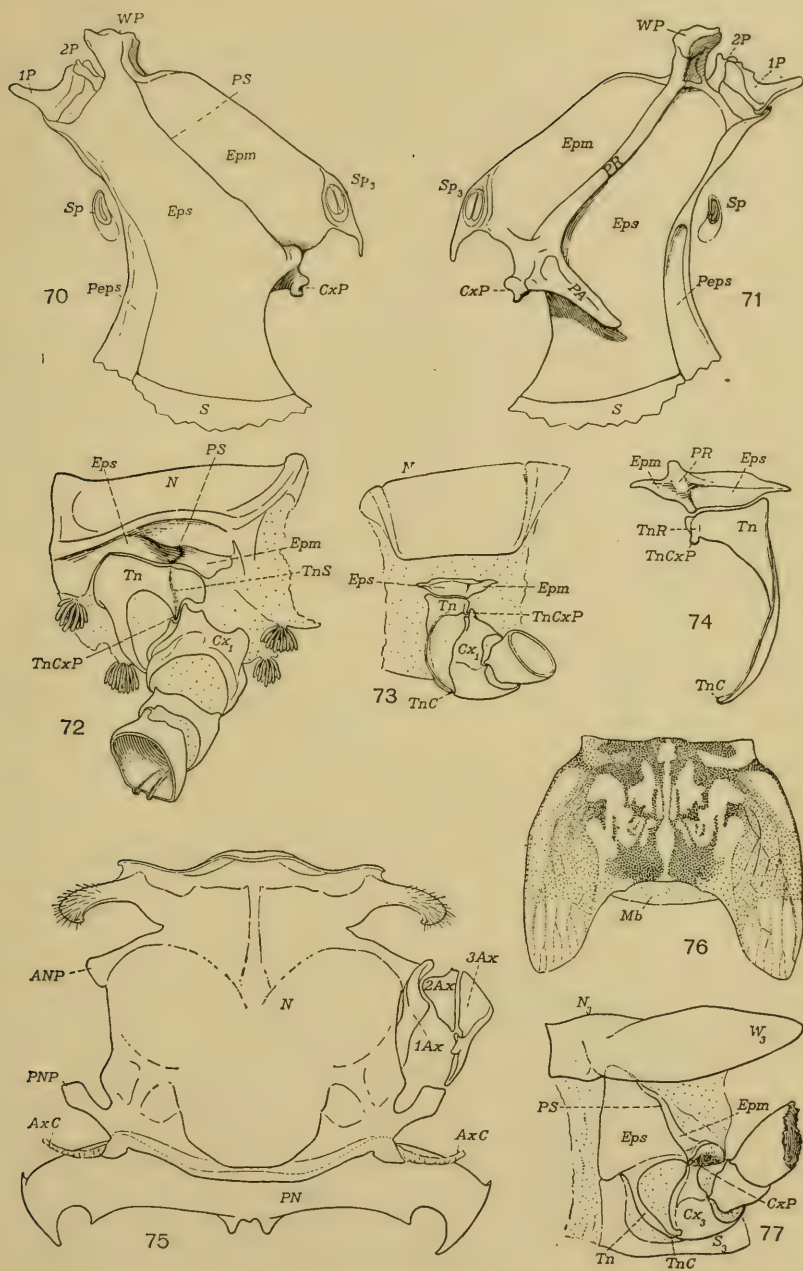


WINGS OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 591.



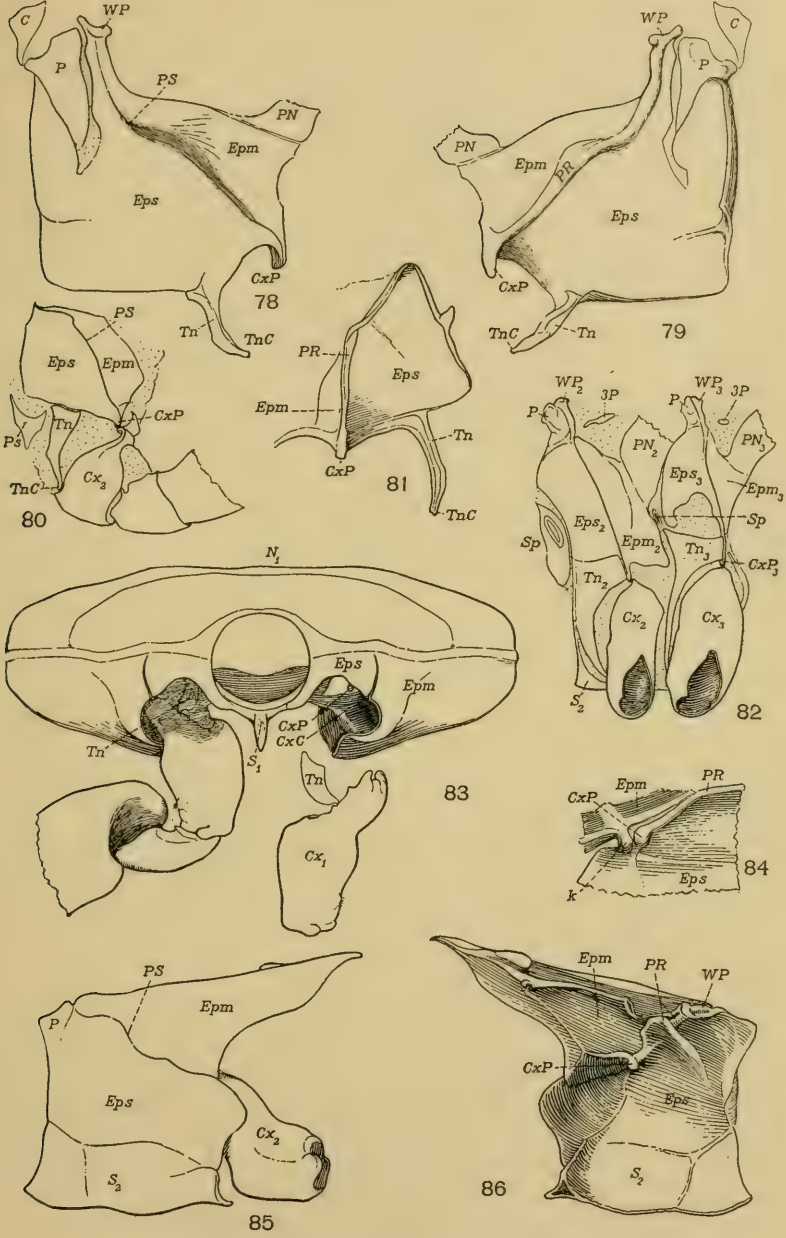




THORAX OF GRASSHOPPER AND STONEFLIES.

FOR EXPLANATION OF PLATE SEE PAGE 591.



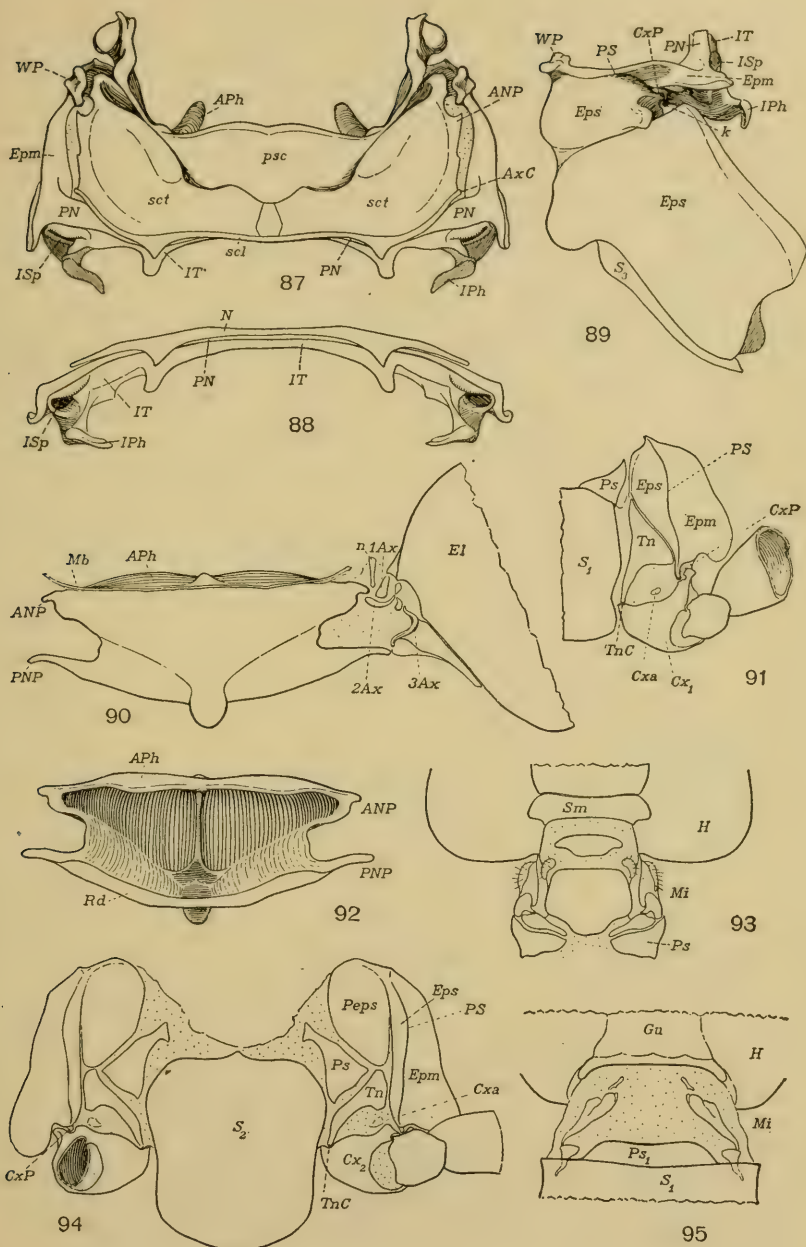


THORAX OF STONEFLY, BARK-LOUSE, AND GIANT WATER-BUG.

FOR EXPLANATION OF PLATE SEE PAGE 591.



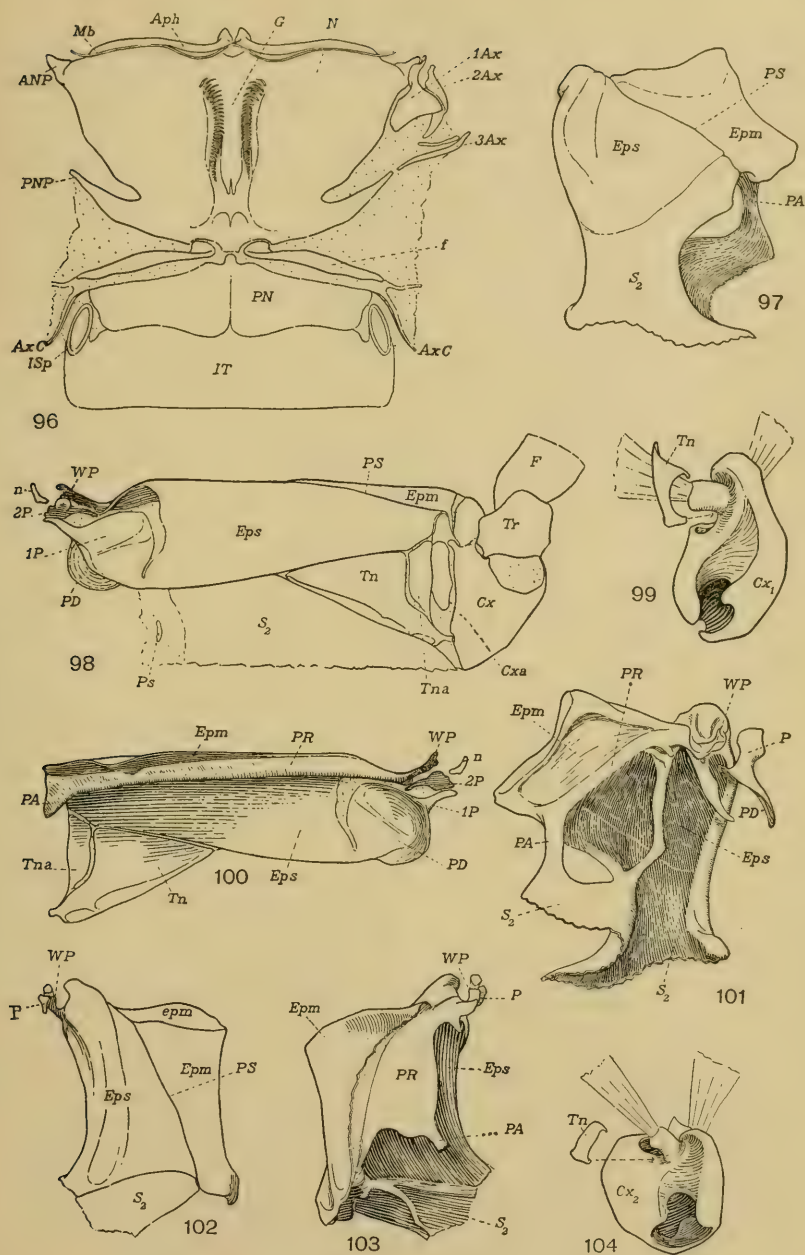




THORAX OF GIANT WATER-BUG AND EARWIG, AND MICROTHORAX OF BEETLE.

FOR EXPLANATION OF PLATE SEE PAGE 591.



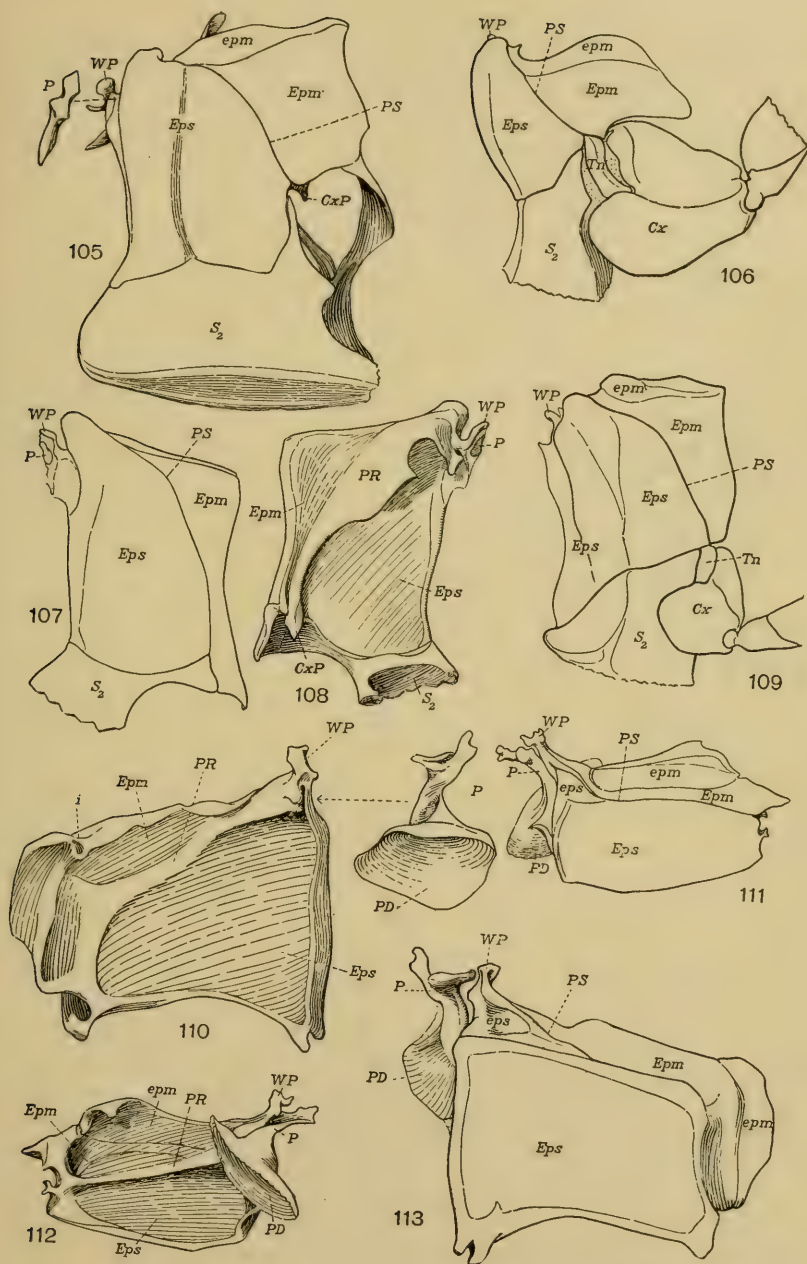


## THORAX OF EARWIG AND BEETLES.

FOR EXPLANATION OF PLATE SEE PAGE 592.



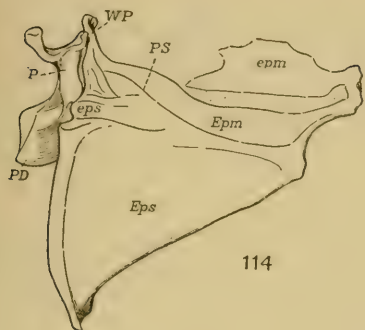




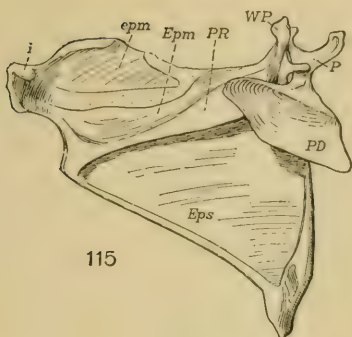
## MESOPLEURUM AND METAPLEURUM OF BEETLES.

FOR EXPLANATION OF PLATE SEE PAGE 592.

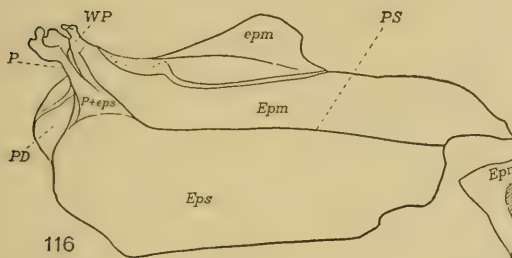




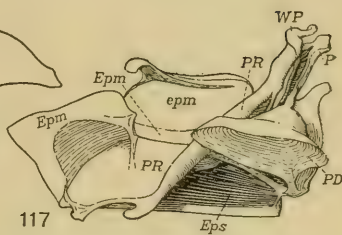
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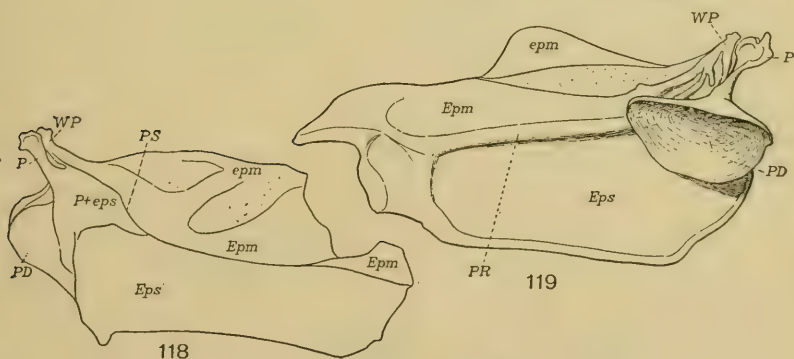
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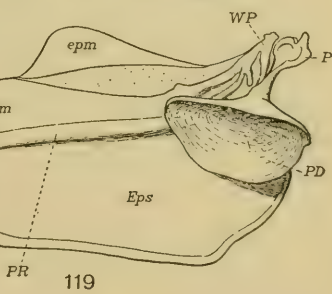
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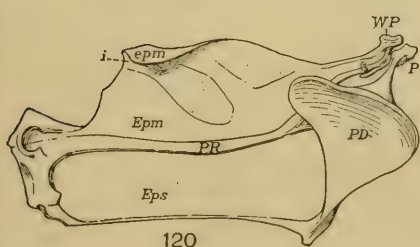
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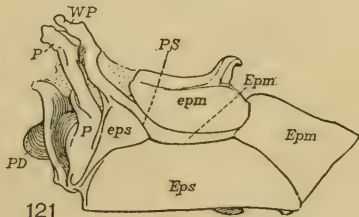
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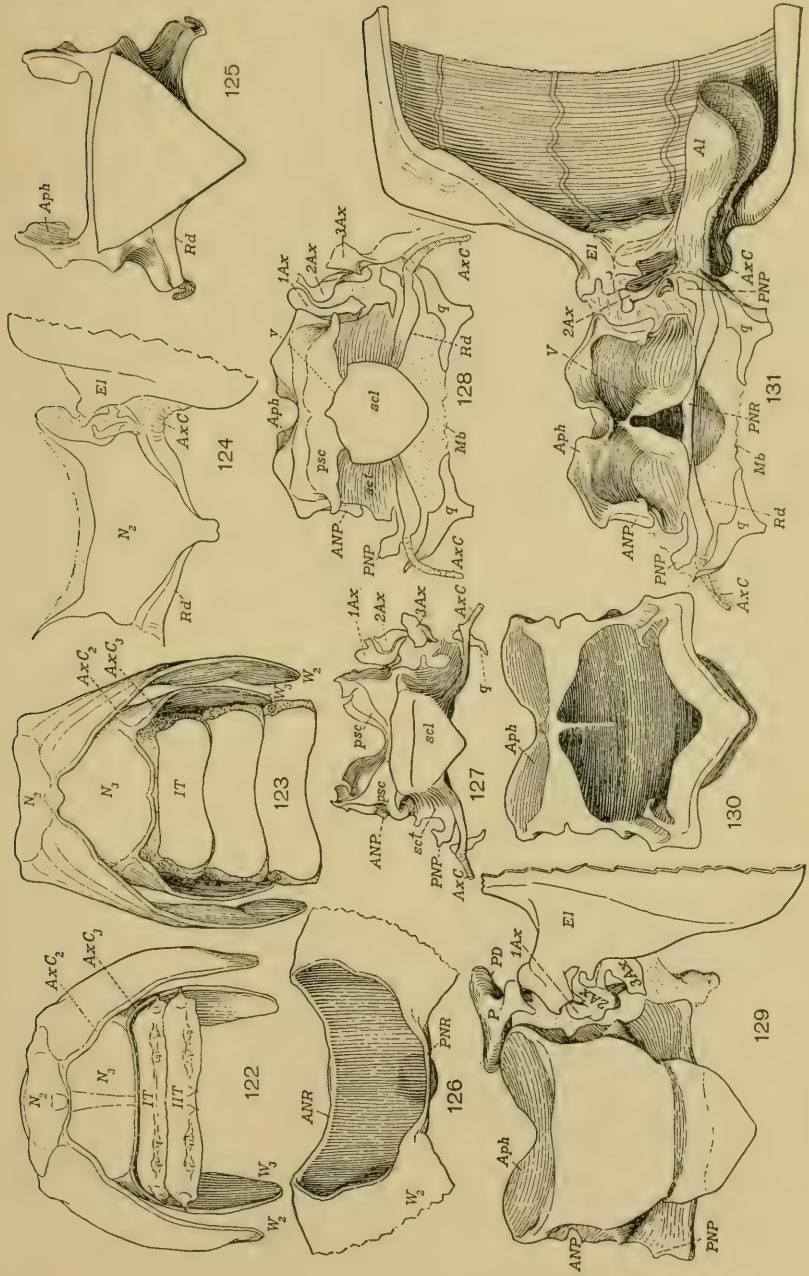
121

# METAPLEURUM OF BEETLES.

FOR EXPLANATION OF PLATE SEE PAGE 592.



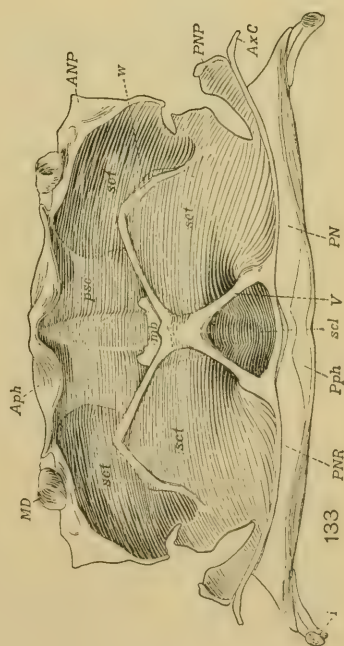
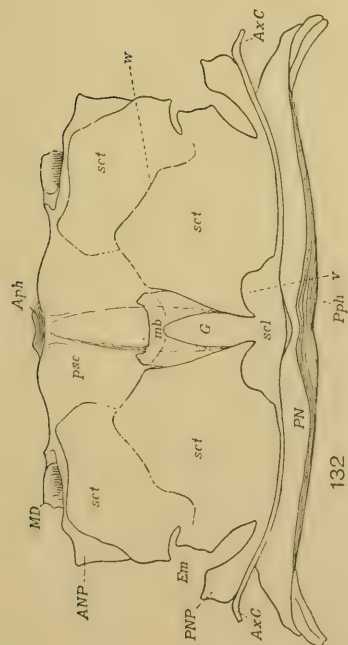
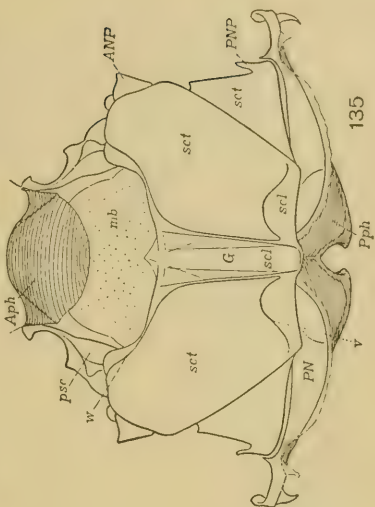
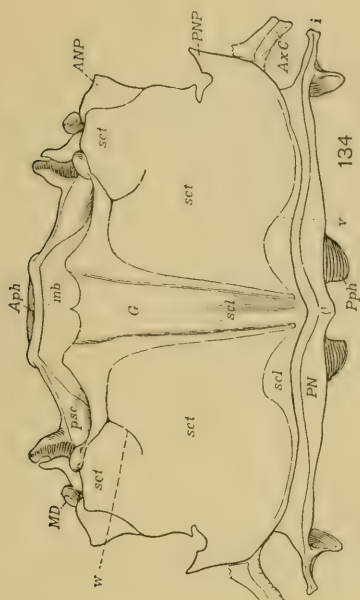




MESOTERGUM OF BEETLES.

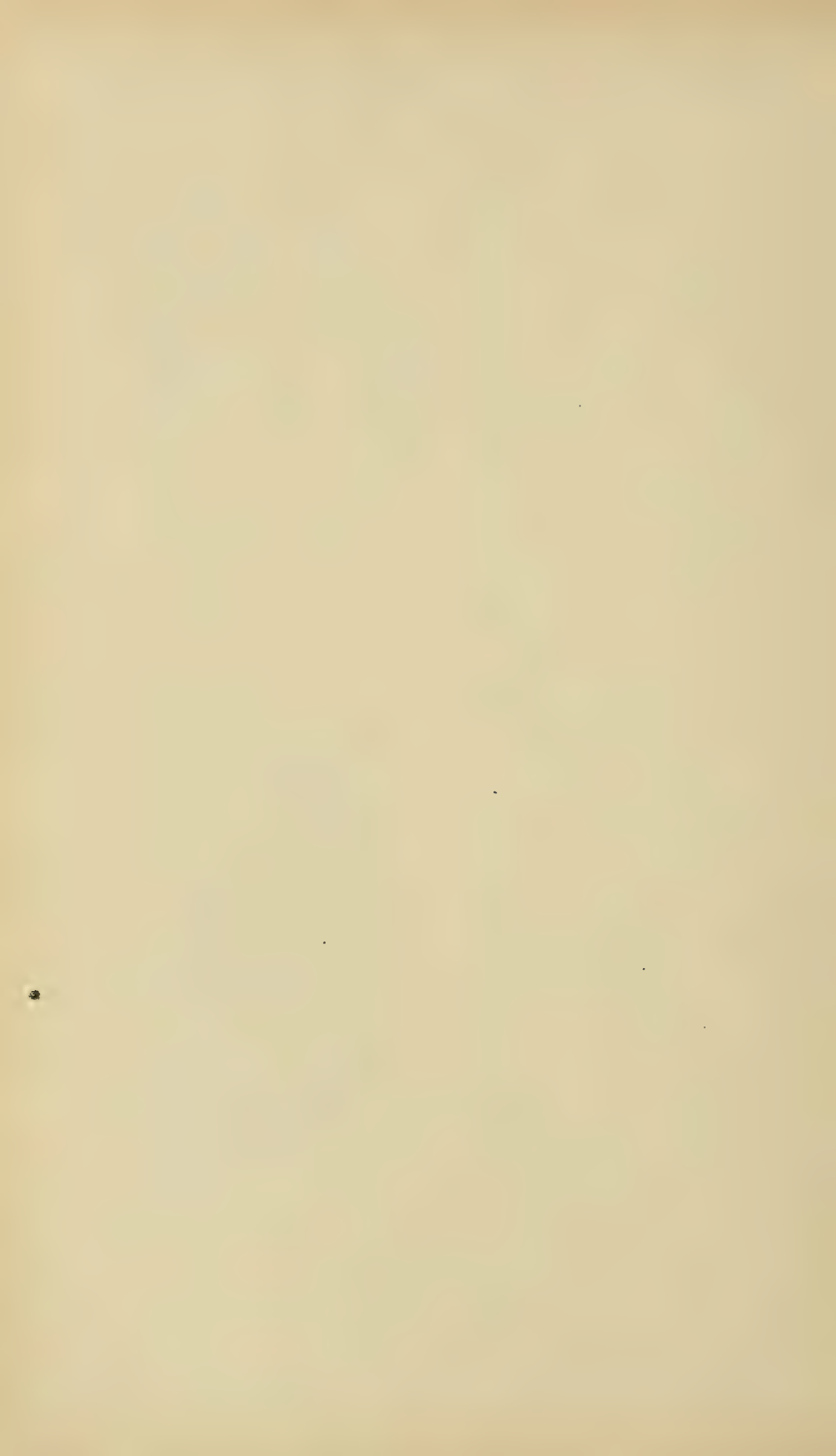
FOR EXPLANATION OF PLATE SEE PAGE 592.





## METATERGUM OF BEETLES.

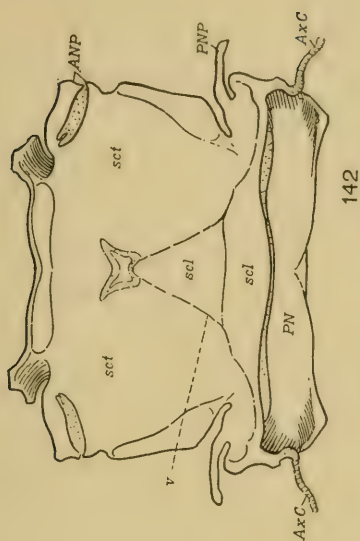
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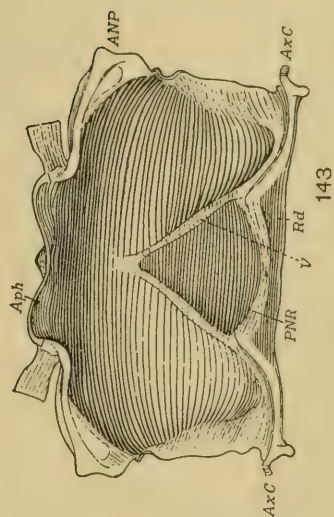




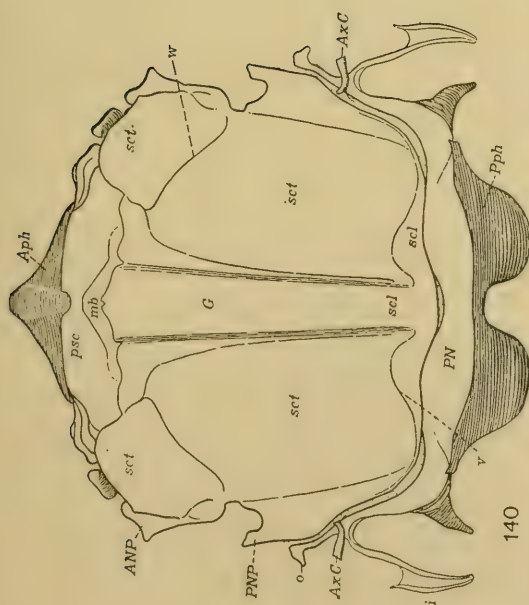




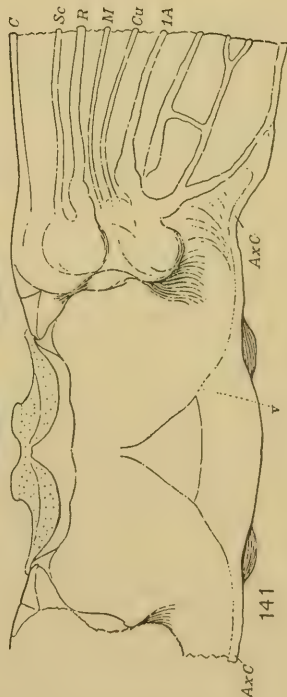
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143



140



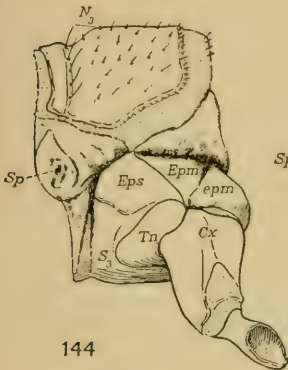
141

METATERGUM OF BEETLE, MESOTERGUM AND METATERGUM OF DOBSON-FLY.

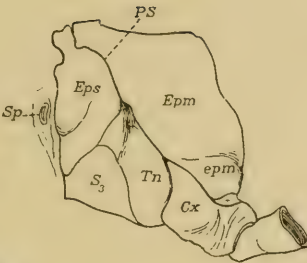
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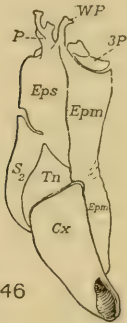




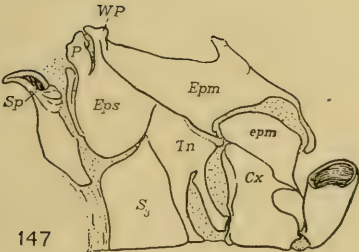
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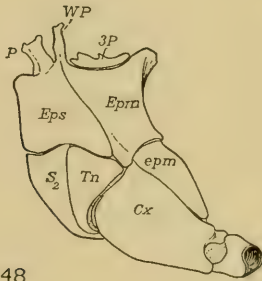
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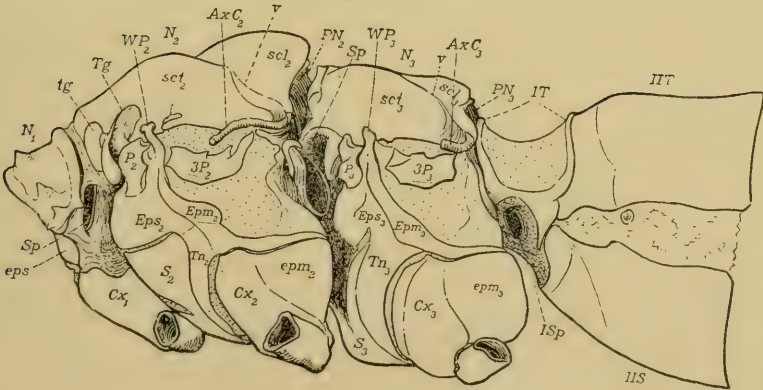
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148

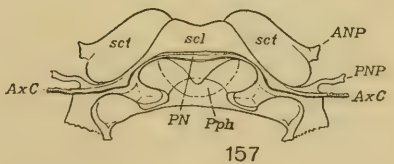
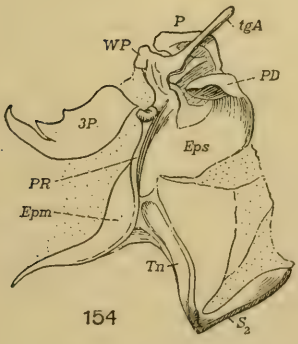
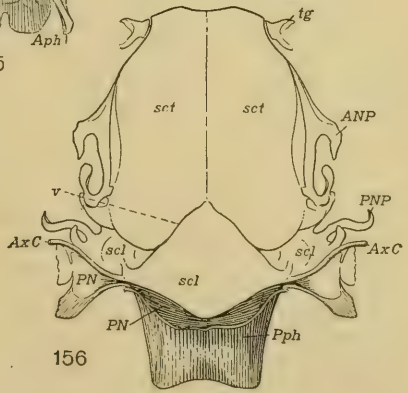
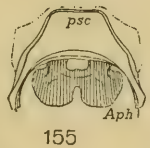
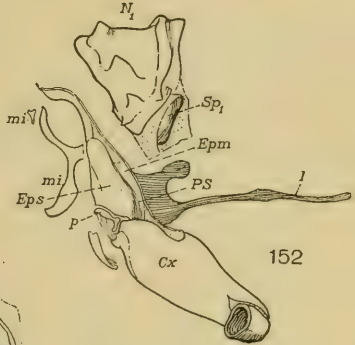
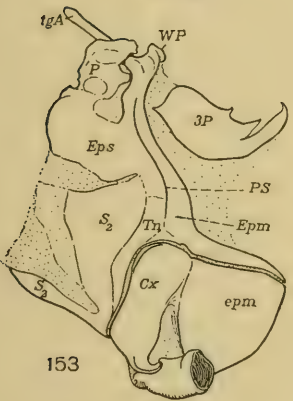
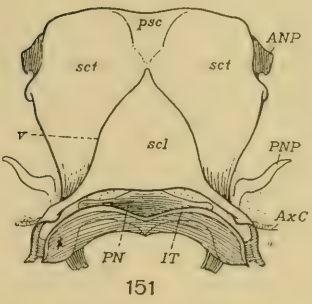
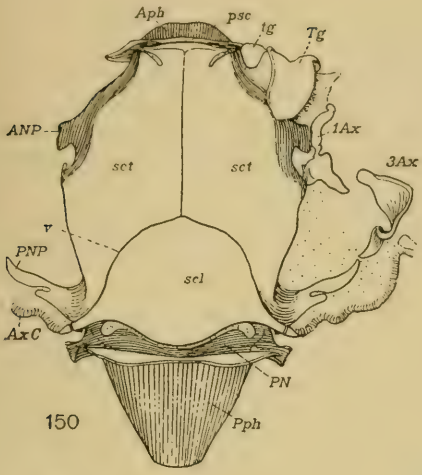


149

THORAX OF DOBSON-FLY, CADDICE-FLY, AND CARPENTER-MOTH.

FOR EXPLANATION OF PLATE SEE PAGE 593.



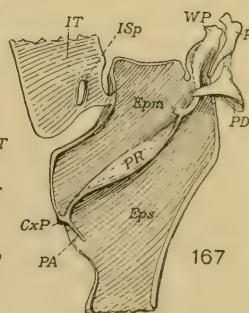
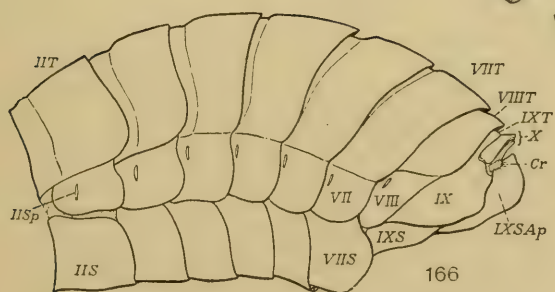
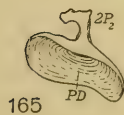
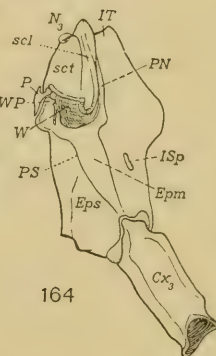
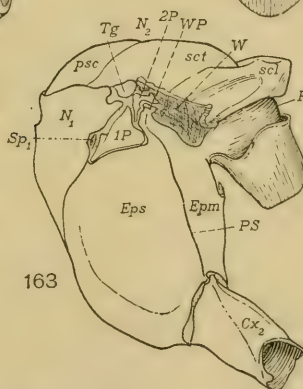
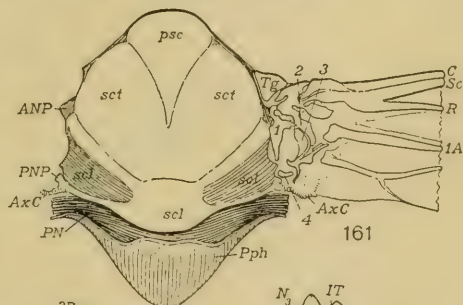
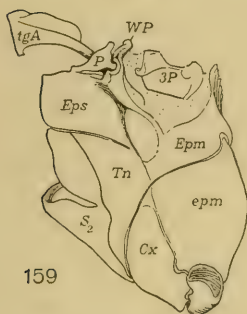
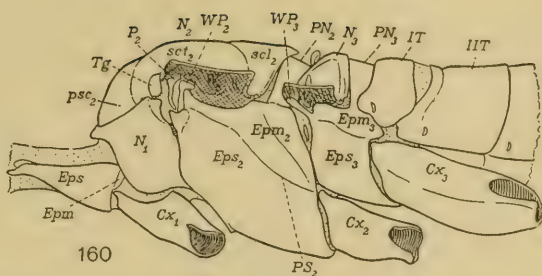
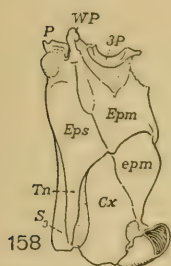


THORAX OF CARPENTER-MOTH AND SPHINX-MOTH.

FOR EXPLANATION OF PLATE SEE PAGE 593.



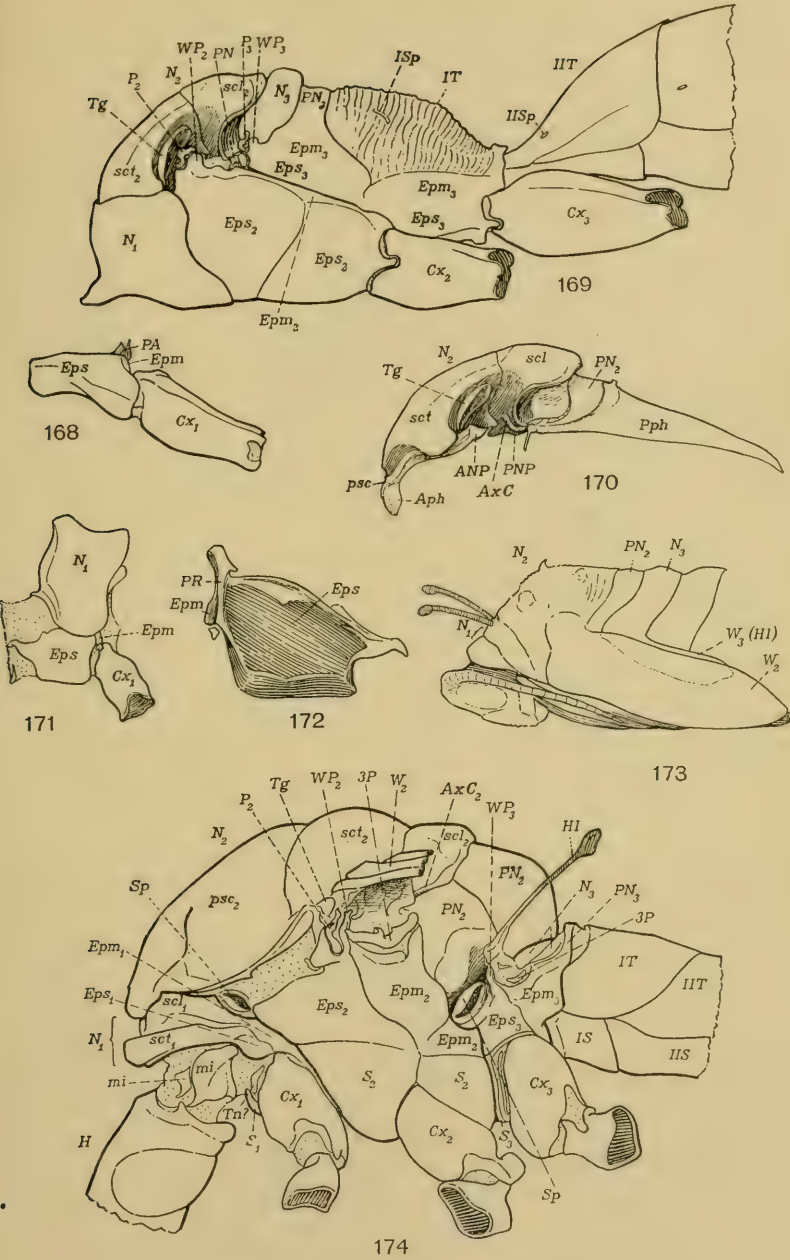




## THORAX OF SPHINX-MOTH AND HYMENOPTERA.

FOR EXPLANATION OF PLATE SEE PAGES 593, 594.



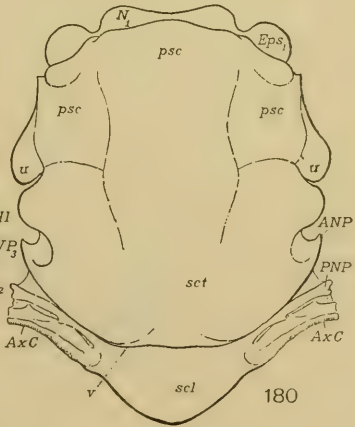
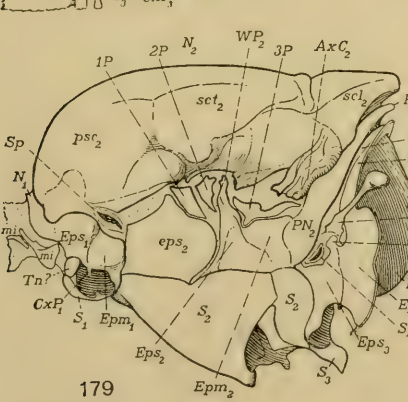
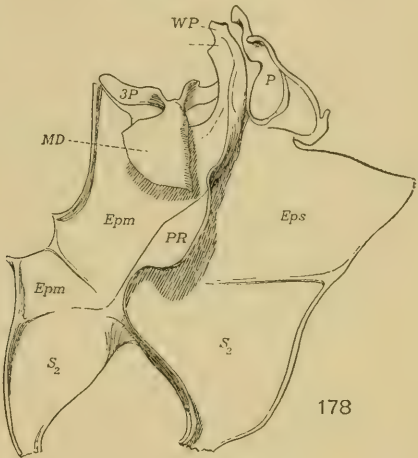
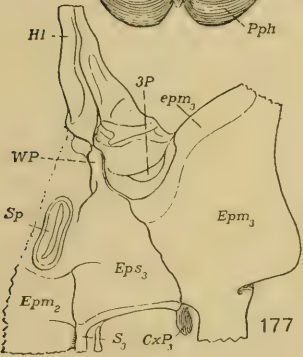
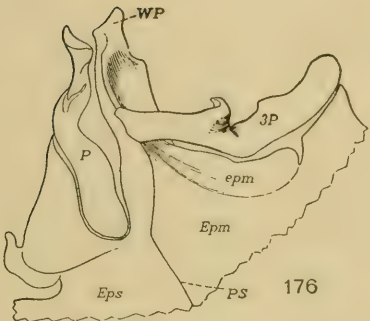
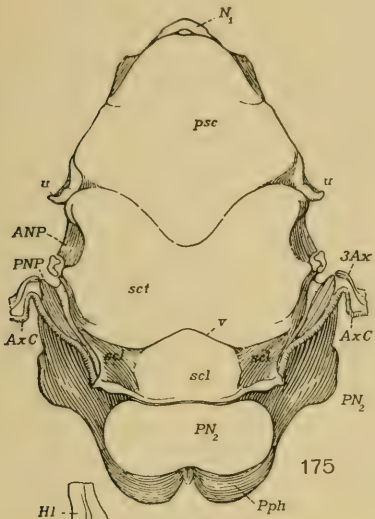


THORAX OF HYMENOPTERA AND CRANE-FLY.

FOR EXPLANATION OF PLATE SEE PAGE 594.



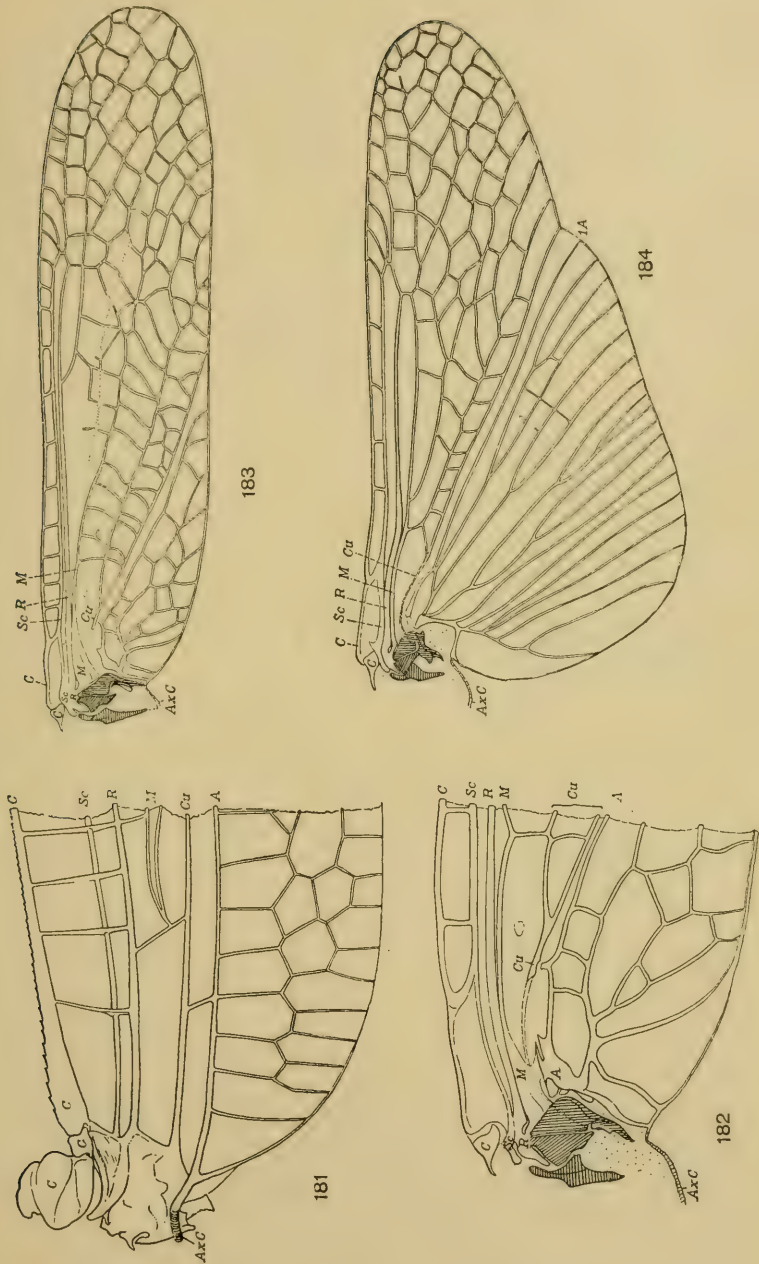




THORAX OF CRANE-FLY AND HORSE-FLY.

FOR EXPLANATION OF PLATE SEE PAGE 594.



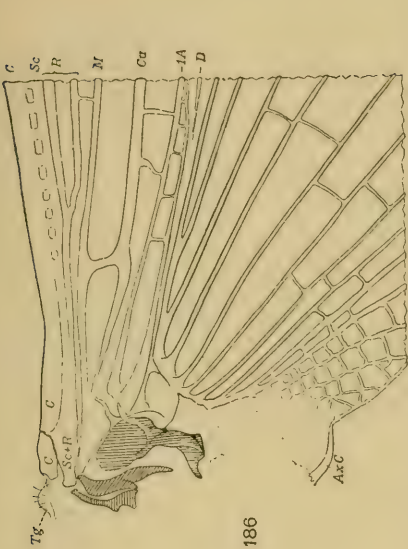


WING BASES OF DRAGONFLY AND STONEFLY, AND WINGS OF STONEFLY.

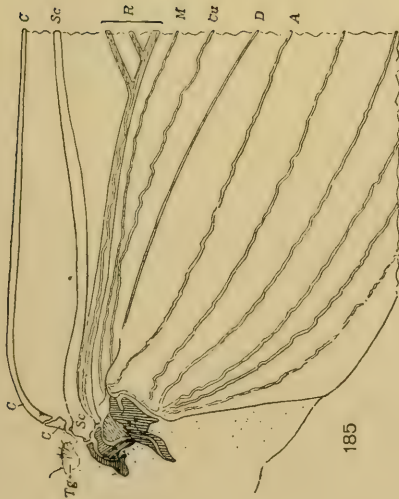
FOR EXPLANATION OF PLATE SEE PAGE 594.







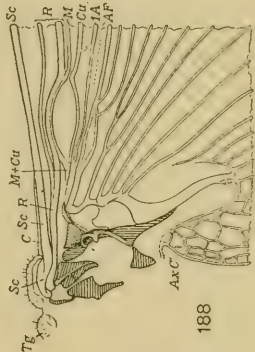
186



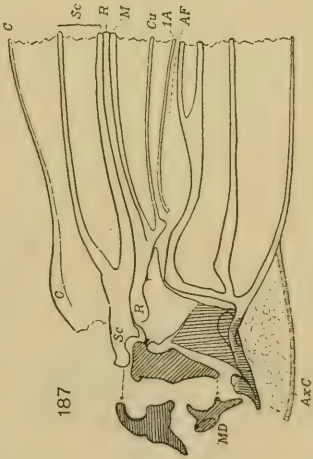
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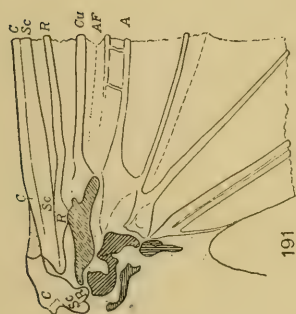
WING BASES OF ORTHOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 594.

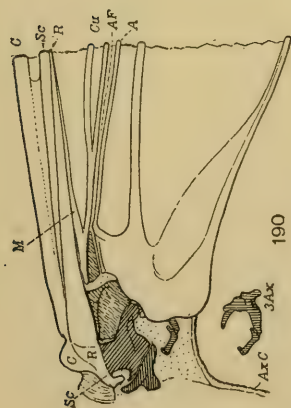




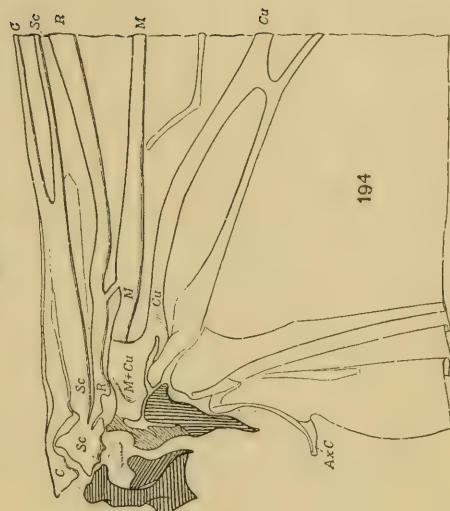
192



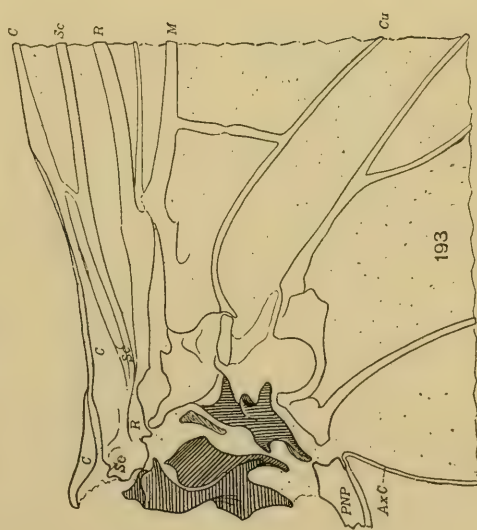
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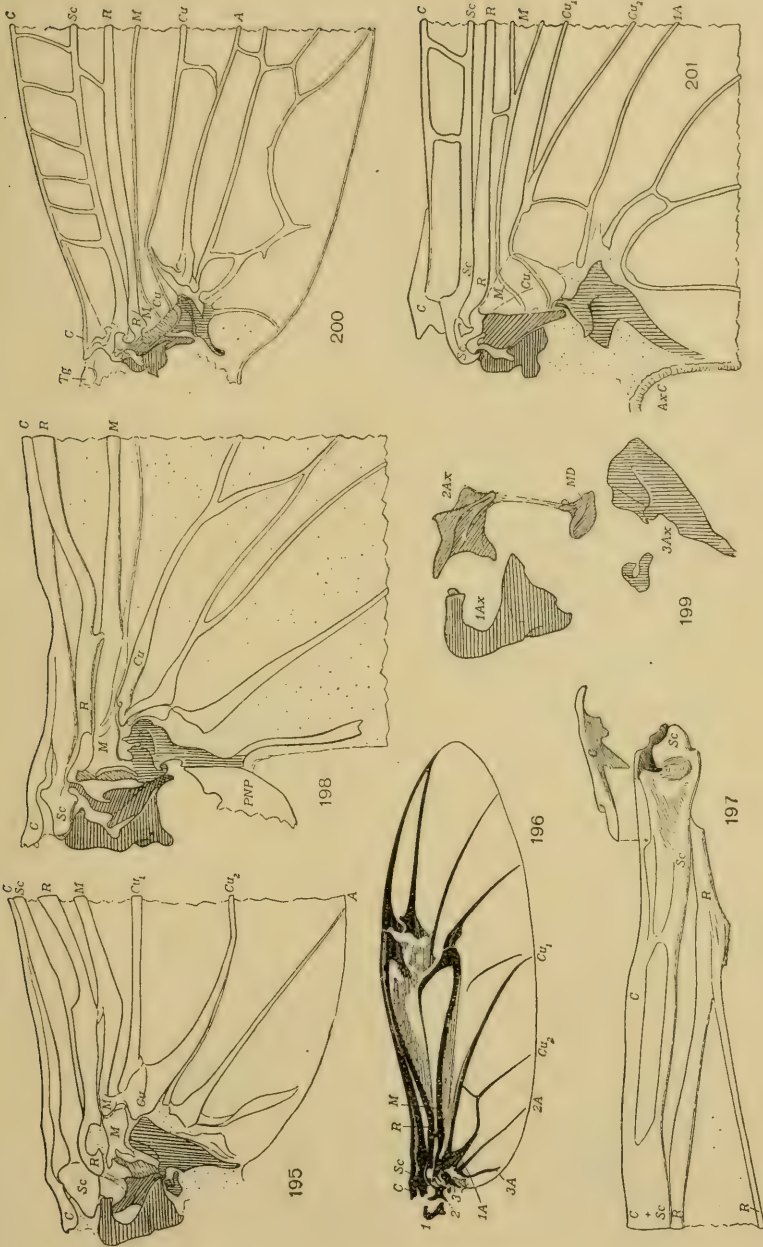
193

## WING BASES OF GIANT WATER-BUG AND BEETLES.

FOR EXPLANATION OF PLATE SEE PAGE 594.



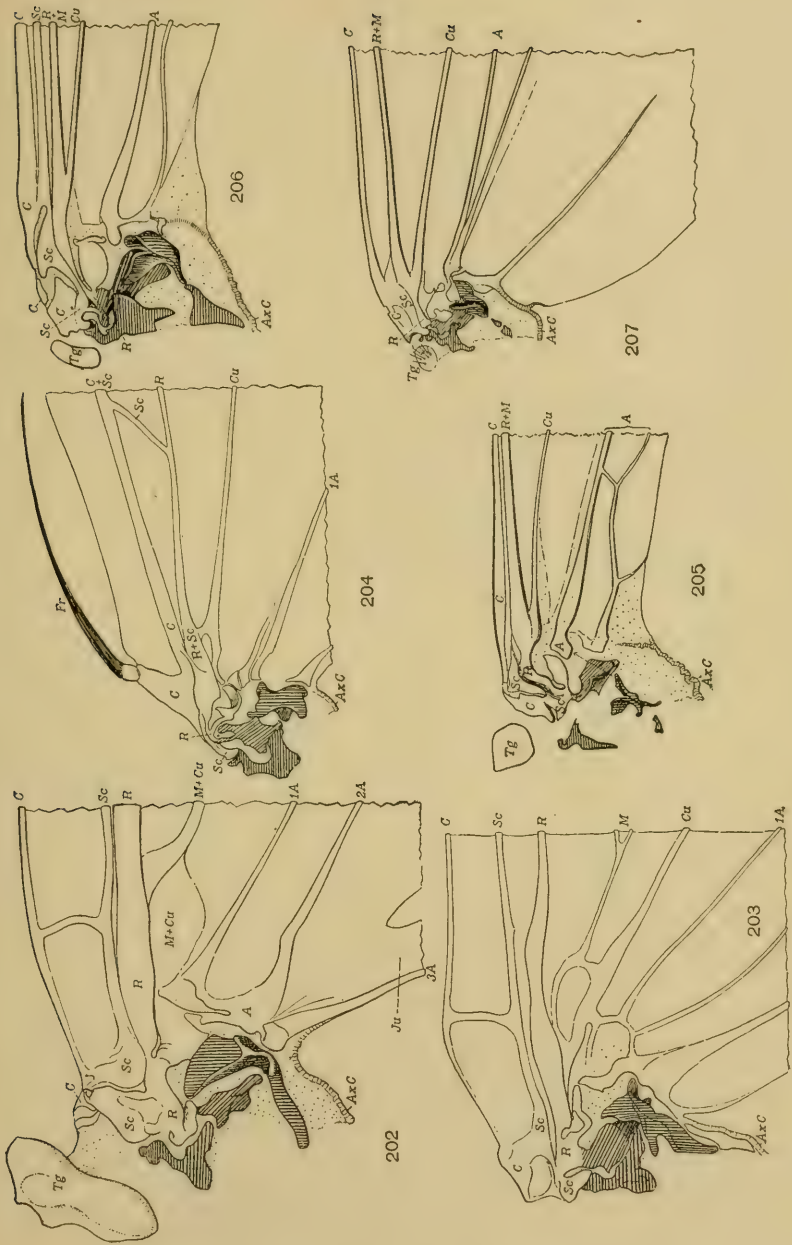




WING BASES OF BEETLES AND DOBSON-FLY.

FOR EXPLANATION OF PLATE SEE PAGES 594, 595.





WING BASES OF MOTHS AND HYMENOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 595.









# DESCRIPTIONS OF NEW GENERA AND SPECIES OF FISHES FROM JAPAN AND THE RIU KIU ISLANDS.

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By JOHN OTTERBEIN SNYDER,  
*Of Stanford University, California.*

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During the recent cruise of the U. S. Bureau of Fisheries steamer *Albatross* in the North Pacific Ocean and in the seas about Japan, many fishes were collected along the shores of Japan and to the southward as far as Okinawa. In the preparation of a report on these fishes a number of new forms have been discovered. Descriptions of 2 genera and 14 species heretofore unknown appear in the present paper.<sup>a</sup>

## Family SYNGNATHIDÆ.

SIPHOSTOMA YOSHI, new species.

Head 9 in length to base of caudal; depth 3.5 in head; eye 5.5; snout 2.5; dorsal 48; rings 18+31.

Body slender, the tail long; dorsal outline of snout concave; interorbital space flat; occiput convex. The snout bears ridges as follows: a median one from the tip to interorbital space; a dorso-lateral one extending from tip to supraorbital rim where it branches on interorbital space; a pronounced median ventral one, and above this a less prominent pair, the upper of which passes below nostrils and eye. Occiput with 3 ridges, the outer ones having their origins above the eye, and continued backward as the dorsal body keels. Ventral surface of body rounded, without a median keel; no spines or very strong keels on body or tail.

Dorsal on 10.5 rings, 4 of which belong with the body; the height of rays about equal to depth of body. Anal minute. Caudal equal in length to snout. Pectoral somewhat over half as long as caudal.

Color in spirits yellowish white; a dusky stripe, indefinite in outline, passing from tip of snout backward across head; body with dusky reticulations which form a row of diamond-shaped figures on

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<sup>a</sup> Other species from the same region are described in a previous paper, Proc. U. S. Nat. Mus., XXXV, pp. 93-111.

the tail, connected by a narrow, median stripe; caudal dusky, with light edges.

*Type*.—One specimen, Cat. No. 62944, U.S.N.M., measuring 105 mm. Locality, Tanegashima, Japan.

(*yoshi*, a Japanese word meaning a reed.)

ICHTHYOCAMPUS NOX, new species.

Head 8.2 in length to base of caudal; depth 18; depth caudal peduncle 7.5 in head; snout 2.5; eye 5; D. 20; A. 3; rings 16+31.

Snout with a strong median keel which abruptly ends on interorbital area; a lateral one of about one-half the height of median keel extending obliquely from tip of snout to eye; a third extending alongside of snout to opercle; another on lower edge of snout; opercle with a keel on anterior third, from which faint lines radiate; supraorbital keels converging toward a short median ridge behind. Body with a median ventral ridge and 3 lateral ones. Tail square in cross section, except on 3 anterior rings over which the median of the lateral ridges extends. Plates of body without spinous angles; those of tail with incipient spines on upper angles

Dorsal extending over 5.5 rings, 5 of which belong with the tail. Caudal equal in length to diameter of eye. Pectoral slightly longer.

Color of preserved specimen almost black; a narrow stripe, scarcely visible, extending along each flat surface; caudal narrowly edged with white.

Described from the type, a female 51 mm. long, from Naha, Okinawa.

*Type*.—Cat. No. 62945, U.S.N.M.

MICROPHIS OCELLATUS, new species.

Head 5.7 in length to base of caudal; depth 1.7 in head; depth caudal peduncle 7; diameter eye 6; length snout 2.5; D. 30. A. 5; rings 19+18.

Body of about equal depth from occiput to tail where it abruptly grows smaller, the outlines of the tail gradually sloping to the caudal peduncle. Snout perceptibly curved upward; narrow, the width slightly less than diameter of orbit; rounded anteriorly. Nostrils with low rims. Head with ridges as follows: one above eye, having its origin on tip of snout, curves outward as it passes back, abruptly bends inward and increases in height on reaching nostrils, then bends outward and curves downward behind the eye and extends to upper edge of opercle; one on occiput; a central, oblique one on opercle with lesser ridges radiating from it; 3 on each side of snout. Each body ring with a median dorsal and ventral keel, except where displaced by egg-pouch or fin; 5 lateral keels, the fourth row of which, counting from above, disappears near vent; the third and fifth rows unite just posterior to vent; caudal rings each with a dorsal, ventral, and



5 lateral keels, each of those of the upper lateral row on both body and tail with a weak posterior spine; facets of rings weakly sculptured between the keels. Egg-pouch extending over 13.5 body rings, the keels on either side of pouch markedly elevated.

Dorsal located on 7.5 rings, 2 of which belong with the tail. Caudal fin obtusely pointed, about half as long as snout. Anal minute. Pectoral about 1.5 times as long as diameter of orbit.

Color in spirits, light brown; 2 distinct dark stripes on occiput, which converge and join on back above pectoral fin and pass in a broken line to caudal; side of head with a broad, dark stripe passing through eye; a row of large spots along lower edge of jaw and on opercle; sides of body with a line of small spots on upper row of plates and a line of sharply defined ocelli on each of the three rows of plates below; tail with small, elongate, dark spots, one on each ring facet; caudal dusky, with a light border.

This description is of a male specimen, 63 mm. long, collected at Naha, Okinawa.

*Type*.—Cat. No. 62946, U.S.N.M.

A female, also from Naha, has 21 rings in the caudal. The keels of the rings are stronger and the surfaces between are more prominently sculptured. There are 29 dorsal rays. The color is less brilliant than that of the male, the ocelli being replaced by small spots.

A female, 39 mm. long, from Tanegashima has 22 caudal rings.

The color is very dark, except for 7 or 8 large, light spots passing over the back like saddles.

*Cotype*.—Cat. No. 21133, Stanford University collection.

### Family APOGONICHTHYIDÆ.

#### APOGONICHTHYS NAFÆ, new species.

Head, 2.7 in length to base of caudal; depth, 2.9; depth caudal peduncle, 5.7; eye, 3.2 in head; snout, 5.5; width interorbital space, 4; D. VII-I-10; A. II-9; scales in lateral series, 23; between origin of anal and spinous dorsal, 8.

Head very large; snout pointed; jaws equal; eye large, the diameter greater than length of snout; maxillary extending beyond eye, its length almost equal to half that of head. Teeth of jaws in narrow bands; no canines; large teeth on vomer, none on palatines. Edge of preopercle, smooth. Border of preopercle with a row of 6 large scales; scales of opercle, large. Lateral line ending beneath origin of soft dorsal; a few scattered pores along middle of caudal peduncle.

First dorsal spine, minute; the second not quite half the length of third; third and fourth longest, about 2.2 in head. Anterior rays of soft dorsal longest, 1.9 in head. First spine of anal minute, the following one very small; longest rays somewhat shorter than those of

dorsal. Caudal rounded, 1.3 in head. Pectoral rather pointed, 1.5 in head. Ventral, 2.2.

Three blackish stripes extending backward from eye toward border of opercle; the median one broadened and rounded posteriorly; body with small, dark spots, those on caudal peduncle largest.

Described from the type, a specimen 30 mm. long, from Naha, Okinawa.

*Type*.—Cat. No. 62947, U.S.N.M.

The species closely resembles *A. isostigma* Jordan and Seale,<sup>a</sup> from which it may possibly prove to be indistinguishable. *A. nafa* has a larger eye and a smaller second anal spine, while in *A. isostigma* the median stripe of head is broader, closely approaching a circular spot in shape, and bordered by a prominent ring of dead white; also each lateral scale of body has a large, black spot.

### Family POMACENTRIDÆ.

#### ABUDEFDUF RICHARDSONI, new species.

Head, 3.8 in the length to base of caudal; depth, 2.5; depth caudal peduncle, 7.2; diameter eye, 2.8 in head; snout, 4.2; width interorbital space, 3; D. XIV-13; A. II-13; scales in lateral series, 26; in transverse series, counting upward and forward from origin of anal, 11.

Mouth oblique; maxillary extending to a vertical through anterior edge of orbit. Teeth incisor-like in front of jaws, the edges rounded; growing more conical and smaller posteriorly; not crowded, the spaces between them quite evident. Gill-rakers on anterior arch, 7+16, long and slender. Suborbital narrow, the edge smooth; edge of preopercle naked and very finely denticulated.

Snout naked between nostrils and lip; head and body otherwise completely scaled; bases of dorsal and anal scaled, the spinous dorsal with three rows of attenuated scales extending upward between the spines. Lateral line ending below origin of soft dorsal; a few pores along median part of caudal peduncle.

Median spines of dorsal somewhat longer than the others, 1.8 in the head; longest (ninth) ray, 1.2 in head. Second anal spine, 2 in head, the first not quite half as long; rays of about equal length throughout, 1.6 in the head. Soft dorsal reaching base of caudal when depressed; neither dorsal nor anal filamentous. Caudal deeply cleft, the lobes somewhat filamentous in a few examples. Pectorals, 3.6 in the length; ventrals, 4; occasionally filamentous.

Color of preserved specimens; base of pectoral with a prominent black spot on its upper third; dorsal half of body dusky, the color gaining in intensity posteriorly and forming a black stripe along upper part of caudal peduncle and caudal fin; lower lobe of caudal

<sup>a</sup> Fishes Samoa, Bull. Bureau Fisheries, XXV, p. 251.

fin with a similar dark border which extends forward and ends near the middle of lower edge of caudal peduncle; scales of body each with a dusky spot, the spots growing less distinct and finally disappearing ventrally; posterior basal part of soft dorsal with a light, yellowish spot, round and well defined in some examples; other parts of fin, together with spinous dorsal, dusky; anal with a well marked blackish border.

Described from the type, a specimen 70 mm. long, and other examples from Naha, Okinawa, among which are the cotypes, Cat. No. 21134, Stanford University Collection.

*Type*.—Cat. No. 62948, U.S.N.M.

The species resembles *P. cyanomus* Bleeker.<sup>a</sup> It is distinguished by the black spot on the base of the pectoral, the absence of a blue spot at upper edge of gill-opening, the less sinuate dorsal, and other less conspicuous characters.

Named for Mr. Robert Earl Richardson.

ABUDEFDUF REX, new species.

Head, 3.6 in length to base of caudal; depth, 2.4; depth caudal peduncle, 6.4; diameter eye, 3 in head; width interorbital space, 3.3; D. XIII—14; A. II—13; scales in lateral series, 25; between lateral line and spinous dorsal, 2; between origin of anal and lateral line, counting upward and forward, 9.

Body moderately elongate, the eye large, snout short and blunt, the maxillary extending to a vertical passing midway between pupil and anterior edge of orbit. Teeth in a single row; conical and close set. Gill-rakers on first arch 5+11; slender and rather short; suborbital smooth; edge of preopercle exposed and smooth.

Lateral line ending below origin of soft dorsal; a number of pores scattered along middle of caudal peduncle. Snout and chin naked; head and body elsewhere scaled; bases of dorsal and anal with a strong sheath of scales, above which several rows of narrow, thin scales extend outward on the membranes; basal half of caudal with scales.

Membrane of spinous dorsal with a scalloped edge, a small filament extending beyond each spine; the posterior spines longest, about 1.6 in head; last rays extending somewhat beyond base of caudal when depressed. Second spine of anal almost equal in length to the following ray, 1.6 in head; longest rays somewhat shorter than those of dorsal, not quite reaching caudal when depressed. First ray of ventral filamentous, reaching slightly beyond origin of anal when depressed, the spine about half as long as the ray. Upper rays of the pectoral longest, 3.8 in the length; the others successively shorter. Caudal with a rather shallow notch, the lobes rounded.

<sup>a</sup>Atl. Ichth. Pomac., pl. ix, fig. 3.



Color in spirits brownish anteriorly, becoming much lighter on posterior half; each scale with a round, white spot, behind which is a small dusky area, the former fading and the latter becoming more distinct on exposure to light; upper edge of gill-opening with a distinct black spot partly covering one scale; 2 or 3 faint light stripes on snout. In life brilliant purple anteriorly, blending with bright orange on posterior half of body, each scale with a round purple spot, the posterior spots standing out in bold contrast against the orange; spinous dorsal narrowly edged with purple, the soft dorsal, anal, and caudal orange; base of pectoral orange, the fin washed with purple; ventrals suffused with purple.

Small examples have the dorsal and anal more elongate than the larger ones.

*Type*.—Cat. No. 62949, U.S.N.M., a specimen 61 mm. long from Naha, Okinawa. *Cotype*, Cat. No. 21135, Stanford University Collection.

Twenty-five specimens were secured from the tide pools, where the species is well represented. Their bright colors make them very conspicuous. When disturbed they quickly conceal themselves in the crevices of the coral rocks.

### Family SCARICHTHYIDÆ.

#### CALLYODON BOWERSI, new species.

Head, 2.9 in length to base of caudal; depth, 2.6; depth caudal peduncle, 7; snout, 2.2 in head; eye, 7; interorbital space, 2.7; D. IX-10; A. II-11; scales in lateral series, 21; between anal and dorsal, 8.5.

Body rather deep and heavy, anterior profile elevated, the head blunt; interorbital space acutely arched. Lips thin and narrow, not covering half of jaws, the upper lip double for a slight space only, the inner part reduced to a small, rounded pad. Teeth whitish, the tips of only one row evident; one short, conical tooth at posterior edge of upper jaw.

Two rows of scales on the cheek; 7 or 8 in the upper, 6 or 7 in the lower; one row along the lower edge of the operculum. Highest dorsal spines, 3.3 in head; rays, 2.8; median anal rays, 2.9. Edge of caudal concave, the length 1.4 in the head. Pectoral rather pointed, 1.3 in head; ventral, 1.7.

Color in spirits deep green, lighter beneath, approaching a yellowish tint on chin and throat; each scale of body with a narrow, light, vertical bar at base; lower lip deep green, narrowly edged with yellowish; upper lip similar; snout with a broad, transverse purplish band which is edged with dark green; interorbital area with two narrow, yellowish bands; lower margin of orbit edged with yellow;



a conspicuous yellow area extending from near eye backward to a vertical through base of sixth dorsal spine, narrow anteriorly, where it is connected with the orbit by two slender stripes, rapidly broadening as it extends backward and downward behind and beneath the pectoral fin; dorsal fins with 2 broad, yellow, median stripes which are united anteriorly; anal with a broad, yellowish green stripe narrowly separated from base of fin; caudal with light stripes between the rays; larger part of pectoral yellowish, the upper edge and the base green; ventrals yellow, edged with green.

*Type*.—Cat. No. 62950, U.S.N.M.

Two specimens from the market at Naha. One, the type, measures 300 mm. in length. The second, cotype, No. 21136, Stanford University collection, is somewhat smaller and a little more brightly colored, the pattern remaining the same. The pectoral of this specimen is somewhat more rounded than that of the type.

Named for Hon. George M. Bowers, United States Commissioner of Fisheries.

*CALLYODON OEDEMA*, new species.

Head, 2.8 in the length to base of caudal; depth, 2.5; depth caudal peduncle, 2.4 in head; eye, 7; snout, 2.1; interorbital space, 3.1; D. IX—10; A. IV—9; scales in lateral series, 22; between bases of dorsal and anal, 7.5.

Body deep and heavy; occiput and nape with a great hump which is angular in front and more rounded above, rising abruptly from a point over anterior margin of orbit. Lips thin, covering only basal portion of teeth; the upper double for about half its width; points of teeth distinct along cutting edge of jaws only; 2 conical teeth on proximal part of upper jaw.

Cheeks with 2 rows of scales, the preopercular margin naked; 7 scales in the lower row, 10 in the upper; posterior part of upper row extending dorsally behind the eye; anterior and upper edge of occipital elevation naked; 3 rows of scales anterior to the dorsal fin. Membrane along edge of spinous dorsal thickened; length of longest spines, 3.5 in head; soft dorsal equal in height to spinous portion, the posterior rays somewhat lengthened. Anal equal in height to soft dorsal, the posterior rays considerably elongated and somewhat falcate, about 2 in head; tips of both dorsal and anal reaching caudal when depressed. Caudal slightly convex, 1.4 in head. Pectoral pointed, the tip, when depressed, reaching a vertical through anal opening. Ventrals pointed, the outer edges greatly thickened, 1.5 in head.

Color in spirits deep brown, the dorsal, anal, and pectoral narrowly edged with green; teeth, deep green.

One specimen, measuring 450 mm. long, from the market at Naha.

*Type*.—Cat. No. 62951, U.S.N.M.

## Family CEPHALACANTHIDÆ.

## DACTYLOPTENA GILBERTI, new species.

Head measured from tip of snout to upper edge of gill-opening, 3.8 in length; depth, 5.3; depth caudal peduncle, 4.3 in head; eye, 3; snout, 3.1; interorbital space, 1.4; D. I-I-V-8; A. 6.

Snout extremely blunt; interorbital space broad and deeply concave; occipital region convex; posttemporal processes short and rather blunt, the space between their apices rounded anteriorly instead of angular; each with a strong dorsal keel which is divided anteriorly and broken up into two rows of sharp elevations much like those on the scales. Opercular spine acute, the outer edge serrated; distance from its tip to end of snout contained 2.6 times in the length.

Scales with strong keels, the posterior edges of which are serrated; sides posteriorly, with a row of 6 large, movable, knife-like scales, the first of which is located some distance anterior to the anal opening; base of caudal with a pair of enlarged, movable scales, each of which has a high, sharp keel. An indication of a lateral line in the shape of a slight ridge without pores may be followed some distance backward and downward from the posttemporal spine.

First and second dorsal spines separate from each other, and from the remaining part of the fin; the first spine very high, extending to tips of other spines when the dorsal is depressed; contained 3 times in the length, inserted immediately behind the occiput, its posterior edge with a broad membrane; second spine short, its length contained about 3.8 times in the length of first; its posterior edge with a membrane which scarcely connects it with the following ray; succeeding spines all connected by membrane, their tips when depressed reaching origin of soft dorsal. Longest (first and second) dorsal rays somewhat shorter than head. Highest anal ray 1.3 in head; edge of membrane between rays deeply scalloped. Longest pectoral rays reaching just beyond base of caudal. Caudal truncate; the uppermost rays slightly longer than the others. Ventrals reaching anal opening.

In spirits the color is a very deep brown, almost concealing a few black spots on the upper and lateral surfaces; first dorsal spine with 6 distinct, blackish cross-bands, the color continuing backward and darkening the membrane; other spines and rays of both dorsals and caudal similarly barred; anal immaculate; pectoral with many round, dusky spots of various sizes, and a large, dusky area near base of fin.

*Type*.—Cat. No. 62952, U.S.N.M., a specimen 208 mm. long from Kagoshima.

The species is represented by but one specimen. It is not to be confused with *D. orientalis*, being readily distinguished by the ex-

tremely short snout, the broad interorbital space, and the curved outline of the area between the posttemporal processes. *D. gilberti* also has the scales more strongly keeled, the tips of the pectoral rays less filamentous, the membranes extending farther out on them, the knife-like scales along the sides better developed and more numerous, and the mouth somewhat wider.

Named for Dr. Charles H. Gilbert.

### Family GOBIIDÆ.

#### ZONOGOBIUS BOREUS, new species.

Head 3.1 in length to base of caudal; depth, 3.7; depth caudal peduncle, 7; eye, 3.2 in head; snout, 4; interorbital space, 4; D. VI—10; A. 8; scales in lateral series about 26; between anal and dorsal, counting upward and forward, about 10.

Head very large; snout blunt, mouth oblique, maxillary extending to a verticle through posterior edge of pupil; interorbital space narrow and flat, the dorsal rims of eyes projecting slightly above it. Teeth simple, in narrow bands on the jaws, the outer and inner row of lower jaw distinctly enlarged; vomer and palatines naked. Tongue truncate. Gill-rakers on first arch 3+10, long and very slender. Gill-openings large, extending far forward below, but not confluent. Shoulder girdle without any apparent armature. Nostrils tubular. Head naked, and without barbels; rows of papilliferous mucous pores on sides of head, snout, and chin. Body with large, loosely attached ctenoid scales, except on breast, abdomen, and a considerable space on back below the spinous dorsal, the scales extending forward toward base of pectoral in one or two rows.

Origin of spinous dorsal slightly posterior to base of pectoral, separate from the soft dorsal; the latter slightly higher, the longest ray contained 1.7 times in the head. Origin of anal on a vertical passing between second and third dorsal rays; the height about equal to spinous dorsal, the longest rays contained 2 times in head; neither dorsal nor anal united by membrane to the caudal peduncle, nor reaching base of caudal when depressed. Ventrals separate, pointed; extending to the anal opening when depressed; inserted directly below the gill-openings. Pectorals rounded, their length contained 1.5 times in the head.

Color in spirits, pale brown, darker on head and neck, where there are a series of light, dark bordered bands, the first of which passes over the snout, curving in front of the eye; the second through eye, the third and fourth across occiput, the fifth over the nape and downward on base of pectoral; between the third and fifth bands are two very light and indistinct ones, which are separated by the fourth. On cheeks, opercles, and base of pectorals the bands are oblique.



*Type*.—Cat. No. 62953, U.S.N.M., a specimen 33 mm. long, from the tide pools at Misaki. Cotype, Cat. No. 21137, Stanford University collection. Only 2 specimens seen.

This species exhibits much the same type of coloration as *Z. semidoliatus* (Cuvier and Valenciennes), and might be mistaken for that form. It differs in being more slender, in having a naked area below the spinous dorsal, and in color.

It may be remarked, in passing, that *Gobius semidoliatus* Day<sup>a</sup> represents a species that has apparently been wrongly identified.

Genus EXPEDIO, new genus.

Body elongate and slender, head broad, the muscles of the jaws greatly developed. Tongue notched. Teeth simple; a band on upper jaw, outside of which is a row of enlarged ones; a single row on the lower jaw. Gill-opening restricted to side of head. A small anal papilla. Body scaleless. Spinous dorsal and ventral fins absent. Soft dorsal inserted above the anal. Middle of back with two parallel rows of minute plicæ.

The genus resembles *Luciogobius*, and is perhaps closely related to it. It differs in having no ventrals.

*Type*.—*Expedio parvulus*, new species.

EXPEDIO PARVULUS, new species.

Head, 5.9 in length to base of caudal; depth, 11; depth caudal peduncle, 11; eye, 8 in head; snout, 3.5; D. 10; A. 11.

Body of about the same depth throughout, the width less than the depth; head broader and deeper than the body; muscles of sides and top of head greatly developed, the interorbital and occipital regions with a marked concavity; rim of eye extending above contour of head. Mouth large, the cleft extending to a point below posterior border of eye; lower jaw projecting beyond the upper; lips large and pendent; tongue broad, very deeply notched at tip; teeth simple, a narrow band on upper jaw, a single series on the lower, outer row on upper jaw enlarged. Gill-opening about equal in width to base of pectoral. Nostrils with well-developed rims. A row of mucous pores extending along snout and backward below eye; a short row behind and above eye. A small anal papilla present.

Head and body scaleless.

Spinous dorsal and ventral fins absent. Soft dorsal inserted on posterior third of body, measured from gill-opening to base of caudal; the rays about equal in height to length of snout. Anal inserted slightly in advance of dorsal, the rays somewhat longer than those of dorsal; caudal rounded; about three-fifths as long as head. Pectorals with 13 rays; the length contained about 2 times in head.

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<sup>a</sup> Fishes, India, p. 295, pl. LIX, fig. 6.



Anal opening located in advance of anal fin a distance about equal to depth of caudal peduncle.

Yellowish white in spirits, closely covered with minute, dark-brown specks.

*Type*.—Cat. No. 62954, U.S.N.M., a specimen 37 mm. long from Misaki, Japan. Cotype, Cat. No. 21138, Stanford University collection. Five specimens in all were secured from the tide pools, the largest measuring 43 mm. In some specimens the pectoral fins were much more pointed and slightly longer than in others.

Genus INU, new genus.

This genus resembles *Luciogobius* and is no doubt related to it. It differs principally in having scales.

Body short, with a deep caudal penduncle; head large, broad, the muscles of the cheeks and sides of the head greatly developed, bulging upward beyond the occiput; eyes directed upward and forward; jaws about equal, the cleft of mouth extending backward far beyond eyes. Teeth simple; an outer row of enlarged ones, within which is a narrow band of minute ones. Tongue notched at tip. Gill-openings restricted to the sides. Shoulder girdle without processes. Pectorals without filamentous rays, ventrals present, well developed and united in a round disk, the anterior edge of which is greatly thickened; spinous dorsal absent; soft dorsal and anal inserted opposite each other, their points of origin near middle of body. Small cycloid scales on posterior part of body; head naked. A small anal papilla. On the back, before the dorsal is a slight median depression, on either side of which is a row of minute, oblique plicae, these being preceded by a slight median ridge. These peculiar plicae are also present in *Luciogobius*, *Clariger*, and *Eupedio*, and they are slightly developed in *Astrabe*.

The genus is known to include two species of voracious-looking little gobies found in the pools at Misaki.

*Type of genus*.—*Inu koma*, new species.

(*inu*, a Japanese word meaning dog.)

INU KOMA, new species.

Head 3.4 in length to base of caudal; depth 7.5; depth caudal peduncle 9; snout 4.5 in head; eye about 10; width interorbital space 9; dorsal 11; anal 12.

The body is short and deep, being almost cylindrical behind the head, growing more compressed posteriorly to the flat caudal peduncle which has a pronounced, thickened, fleshy keel on the upper and lower edges of its posterior half. Head very broad, somewhat over a third wider than the body, and considerably depressed, the great muscles of the cheeks and sides of head bulging outward and upward, thus forming a deep trough behind the eyes and on the

occiput. Interorbital space broad, slightly concave; with a narrow, transverse, fleshy ridge. Eyes directed upward and forward in a marked degree, the upper orbital rims projecting above dorsal contour of head. Nostrils with low rims. Mouth very large, the maxillary extending far beyond eye, its length contained about 2.5 times in the head. Tongue with a deep notch anteriorly. A single row of widely spaced, enlarged, simple teeth in each jaw, within which is a band of minute teeth. Gill-opening restricted to the sides, the opening somewhat greater in width than base of pectoral fin.

A low ridge with a line of large mucous pores extending across snout and backward along side of head below eye; a similar ridge with its crest of mucous pores extending along lower jaw; anterior part of body with a median lateral series of pores. Head and body naked except the caudal peduncle which is closely covered with minute, cycloid scales, the area thus protected extending anteriorly, and growing narrower is reduced to a point below the middle portion of the dorsal fin.

Dorsal and anal inserted almost halfway between edge of gill-opening and base of caudal, the dorsal slightly higher than anal, the longest ray contained about 2.3 times in length of head. Caudal rounded, 1.5 in head. Pectoral rounded, 2 in head. Anterior part of ventrals thickened, the posterior part with weak rays and thin membrane.

Color in spirits, pale brown, finely stippled with dark brown; darker on the snout and on base of caudal where there is a distinct vertical bar; fins with small and distinct dark spots.

*Type*.—Cat. No. 62955, U.S.N.M., described from the type, a specimen 39 mm. long, from Misaki, Japan. Another specimen, cotype, Cat. No. 21139, Stanford University collection, about half as large, does not appear to differ from the above.

(*koma*, a Japanese word; *Koma-inu* the name of one of the two ever-present, dog-like images found in the Shinto temple grounds.)

INU AMA, new species.

Head 3.3 in length to base of caudal; depth 5.6; depth caudal peduncle 7; snout 4 in head; diameter eye 7; width interorbital space 4; dorsal 9; anal 10.

Body notably short and thickset, the depth somewhat greater than the width; caudal peduncle almost as deep as body, and very flat. Head much broader than body, the huge muscles of cheeks and sides of head bulging outward and upward, forming a ridge across the occiput, and a deep pit, open in front, on the top of head. Eyes placed high in head, their dorsal rims projecting above contour of head; directed considerably upward and forward. Nostrils with rims. Mouth large, the cleft extending far behind eye; lower jaw

projecting a little beyond the upper; tongue with a deep notch. Teeth simple, in bands on both jaws; the outer row distinctly enlarged and widely spaced. Gill-openings restricted to the sides; considerably wider than base of the pectoral fin.

Skin of head very soft, lying in numerous small wrinkles and folds; mucous pores apparently absent; no papillæ or marked dermal ridges; back with a row of minute dermal plicæ on each side of median line for a short distance anterior to dorsal fin. Head, back, breast, and abdomen scaleless; posterior parts with minute, cycloid scales; the area thus covered diminishing in width anterior to origin of dorsal, and narrowing down to a point just behind insertion of pectoral fin.

Dorsal and anal inserted opposite each other, their points of origin about midway between bases of pectoral and caudal. Anal somewhat higher than the dorsal, and with a slightly longer base, the rays of either not reaching base of caudal when depressed. Caudal rounded posteriorly, its length contained about 2 times in head. Pectoral rounded, about equal in length to caudal. Ventrals with anterior part greatly thickened; rays slender and rather weak; edges of fin notched, the tips of rays projecting.

Color in alcohol, pale brown, the head with minute subdued spots of a darker color; fins with minute spots.

One specimen (type, Cat. No. 62956, U.S.N.M.), measuring 40 mm. in length, was found in a tidepool at Misaki.

This species is to be distinguished at a glance from the preceding by the more robust body which is more closely covered with scales. On close inspection, many lesser differences appear, as the fewer dorsal and anal rays, the absence of conspicuous mucous pores, etc.

(*ama*, Japanese from Ama-inu, a temple image resembling a dog.)

### Family SOLEIDÆ.

#### TRULLA ITINA, new species.

Head, 5 in length; depth, 3.6; eye, 8 in head; snout, 3.2; dorsal rays about 95; anal, 89; scales in lateral series about 86.

Body sinistral; long and slender, much like the leaf of a willow or bamboo, the snout rather pointed. Eyes separated by a concave, fleshy isthmus, the width of which equals half the longitudinal diameter of the eye. Mouth nearly symmetrical in shape; rostral hook not extending to a vertical through anterior edge of upper eye; angle of mouth below posterior part of lower eye; upper lip of blind side double, the inner portion with a distinct fringe on the edge; no teeth on the left side; a narrow band of minute teeth on the right side. Gill opening of right side somewhat wider than that of the left. A single tubular nostril on left side directly in front of lower

eye; two nostrils on blind side; the anterior tubular, the posterior with a large flap.

Three lateral lines on the left side; the dorsal one beginning on the snout and following along the base of the dorsal fin for about two-thirds of the length of the body; the median one originating on the snout and extending to the tip of tail, sends a short branch upward on the back of head, and another downward across the gill cover toward the ventral fin from where it is continued along the body near base of anal and disappears at a point below end of dorsal line; no lateral line on the right side. Scales all ctenoid; growing smaller in size from the posterior parts toward the head; 12 or 13 scales between the median and dorsal lateral lines near middle of body; 17 between median and lower lines at a point about a head's length behind gill-opening, counting upward and forward in each case.

Pectorals absent. One ventral present, it being located on the median line, and separated from the anal.

Color of preserved specimen light brown, slightly variegated.

The species seems to be distinguished by the three lateral lines on left side, single nostril on left side, and the fringed lip.

*Type*.—Cat. No. 62957, U.S.N.M., a specimen 115 mm. long, from the market at Naha, Okinawa.



# NOTES ON THE FOSSIL MAMMALIAN GENUS *PTILODUS*, WITH DESCRIPTIONS OF NEW SPECIES.

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## INTRODUCTION.

The recent fortunate discovery of a fine specimen of *Ptilodus*, in which the lower jaws and some other parts of the skeleton are associated with a nearly complete skull, not only adds materially to our knowledge of this genus, but makes possible the clearing up of much of the confusion still existing regarding the classification and relationships of the entire Multituberculate (Allotheria) group.

In view of the very fragmentary material hitherto representing this great group of mammals this new material is of more than usual interest and importance. The comparative completeness of the specimen permits for the first time a fairly accurate study of the morphology of the little creature, and makes it possible to determine its relationships with more certainty than has hitherto been done.

This interesting specimen represents a new species which is described below. It is from the Fort Union beds of Sweet Grass County, Montana, where it was found by Mr. A. C. Silberling in the spring of 1908 while collecting fossil mammals in that locality under a special grant from the United States Geological Survey. In this and subsequent collections obtained by Mr. Silberling through a continuation of the work by the U. S. National Museum, there are disassociated upper and lower jaws of several other individuals of this and a second species of the genus. The greater part of this collection, however, consists of numerous specimens, mostly teeth and jaws, representing a large number of genera and species of Basal Eocene mammals, many of them closely related to or identical with species from the Torrejon of New Mexico. Several of the forms are apparently new, and when studied will be published.

Before describing this new species of *Ptilodus* it seems desirable to first give a short history of the genus and a summary revision of the Torrejon and Fort Union species already referred to it.

*Ptilodus*, a genus of the Plagiaulacidae, was proposed by Cope in 1881, the type-species, *P. mediavus*, being founded on a single lower premolar, *p*<sub>1</sub>, from the Torrejon beds of New Mexico. Other specimens, some representing the complete lower dentition, have since been referred to this species, but the upper dentition has not been known. In 1884 Cope proposed a second genus, *Chirox*, basing the type-species, *C. plicatus*, on a series of three upper premolars. This and a second specimen, consisting of a palate containing most of the upper dentition, which was later described and figured by Cope, constitute the principal material referred to this second genus. Both specimens are from the same beds as those from which the type of *Ptilodus mediavus* was obtained. In 1887 Cope<sup>a</sup> questioned whether the specimens referred to *Chirox* might not belong to *Ptilodus*, but deciding they did not, proposed a new family, the Chirogidae, for the former genus, which he considered allied to the Polymastodontidae, regarding the family as a connecting type between the Plagiaulacidae and the Polymastodontidae. In classifying the Allotheria in 1888, Osborn<sup>b</sup> placed *Chirox* in the Bolodontidae, a family proposed by him in 1887.<sup>c</sup>

It is thus evident that the uncertainty regarding the relationships and systematic position of these species has been considerable. The confusion, however, has been largely due to lack of associated material, therefore it is with more than ordinary interest that we come to examine the present specimen from Montana, in which the complete upper and lower dentition has for the first time been found in undoubted association. This specimen has the lower jaws and teeth of *Ptilodus* and the upper teeth of *Chirox*, a fact that has not been wholly unsuspected, though none the less interesting and important in the confirmation. Thus, in proving the synonymy of these two genera the family Chirogidae, proposed by Cope, is finally and satisfactorily disposed of. Incidentally, it also apparently confirms indirectly the opinion expressed by Marsh<sup>d</sup> regarding the probable identity of the genera *Bolodon* and *Plagiaulax*. This opinion, which he gave in criticising Osborn's classification of the Mesozoic Mammalia, is expressed as follows: "A careful study, moreover, of the known species of the true Plagiaulacidae would have shown him the strong probability, at least, that the genus *Bolodon*, which he makes the type of a distinct family, is based on the upper jaws of *Plagiaulax*." This supposition now seems confirmed, for, as is generally conceded, *Ptilodus* bears an undoubtedly close relationship to the much older form *Plagiaulax*, known only from the lower teeth, while

<sup>a</sup> Amer. Naturalist, XXI, 1887, p. 567.

<sup>b</sup> Journ. Acad. Nat. Sci. Phila. (2), IX, Pt. 2, 1888, p. 219.

<sup>c</sup> Proc. Acad. Nat. Sci. Phila., 1887, p. 285.

<sup>d</sup> Idem, 1891, p. 239.

*Chirox*, now known to be *Ptilodus* also, has been shown by Osborn to hold a similar relationship to *Bolodon*, a contemporary of *Plagiaulax*, and similarly known only from the upper teeth. There seems, therefore, little doubt that, as in the case of *Ptilodus* and *Chirox*, the genera *Plagiaulax* and *Bolodon* were founded on the lower and upper teeth, respectively, of individuals representing the same species or, at least, species not generically distinct. If this be true, the family Bolodontidæ is also invalid.

With the important addition to our knowledge of the Allotheria supplied by this more complete material from Montana, the necessity of a further revision and reclassification of the whole group becomes apparent. The present paper is intended, however, only as a preliminary communication, hence it is confined principally to the *Ptilodus* group.

### Family PLAGIAULACIDÆ Gill.

#### Genus PTILODUS Cope.

*Generic characters*.—With the added characters shown in the new specimen described below, the genus *Ptilodus* may now be redefined as follows:

*Dental formula*.— $i_1^1$ ,  $c_0^1$ ,  $pm_3^2$ ,  $m_3^2$ . Incisors simple with sharp, pointed tips, upper and lower pairs not directly opposing each other; upper canine and first three premolars well developed and functional, though not directly opposing the teeth of the lower jaw;  $p^3$  with 4 to 6 cusps;  $p^4$  the largest tooth of the upper series, greatly elongated anteroposteriorly, multituberculate;  $m^1$  multituberculate, with two complete rows of tubercles and a third vestigial row, confined to the posterior half, on the inner side of the crown;  $m^2$  shorter and broader than  $m^1$ , with three short rows of tubercles. In the lower jaw,  $p_1$  and  $p_2$  are wanting and  $p_3$  is rudimentary, with a rounded bead-like crown, which fits into a depression at the anterior end of the large  $p_4$ ;  $p_4$ , the principal tooth of the lower series, greatly elongated and laterally compressed, forming a thin cutting blade with numerous (12 to 14) parallel ribs on either side.

#### PTILODUS MEDIÆVUS Cope.

*Ptilodus mediævus* COPE, Amer. Naturalist, XV, 1881, p. 921.

*Type-specimen*.—A single lower fourth premolar. (No. 3019, Amer. Mus. Nat. Hist. Coll.)

*Neotype* (Cope).—Portion of a right lower jaw representing the complete lower dentition. Amer. Mus. Nat. Hist. Coll.<sup>a</sup>

*Type-locality*.—Northern New Mexico.

*Horizon*.—Torrejon formation.

<sup>a</sup> Cope, Amer. Naturalist, 1884, p. 694; Rep. U. S. Geol. Surv. Terr., III, p. 1, 1884, pl. xxiii, fig. 1.

This species, the type of the genus, was founded on a single lower premolar and was later supplemented by portions of jaws of other individuals. The following definition is compiled from descriptions given by Cope and Osborn, which have been verified or corrected by a recent examination of the type-material:

*Dental formula.*— $i_1$ ,  $c_0$ ,  $pm_2$ ,  $m_2$ ; premolars 1 and 2 wanting;  $p_3$  vestigial;  $p_4$  greatly enlarged, with high compressed crown, which is developed into a sharp, serrated cutting blade, which has 12 (14?) parallel oblique ridges on either side;  $m_1$  narrow and elongate, with 4 internal and 5 external tubercles;  $m_2$  much shorter and somewhat broader than  $m_1$ , with 2 inner and 3 outer tubercles. Upper dentition of this species not known.

*Measurements of type.*—Diameters of  $pm_4$ : anteroposterior, 9 mm.; transverse, 3 mm.; height, 6 mm.

*Measurements of neotype* (after Cope).—Length of ramus to last true molar, inclusive, 20.5 mm. Diameters of  $m_1$ : anteroposterior, 4 mm.; transverse, 2 mm. Diameters of  $m_2$ :<sup>a</sup> anteroposterior, 2.5 mm.; transverse, 2.2 mm. Diameters of  $pm_4$ : anteroposterior, 8.5 mm.; transverse, 3 mm. Vertical diameter of  $pm_4$  at middle, 4.5 mm.

#### PTILODUS TROUESSARTIANUS Cope.

*Ptilodus trouessartianus* COPE, Amer. Naturalist, XVI, 1882, p. 686.

*Type-specimen.*—A fourth lower premolar in a fragment of jaw. (No. 3025, Amer. Mus. Nat. Hist. Coll.) Paratypes: Two additional fourth lower premolars of other individuals.

*Type-locality.*—Northern New Mexico.

*Horizon.*—Torrejon formation.

The description, as given by Cope, is as follows:

This species is represented by three of the characteristic fourth inferior premolars, one of which stands on a part of the ramus, giving its depth. These differ from those of the *P. mediavus* in their uniformly smaller size and in their strongly serrate posterior edge. The number of lateral edges [ridges] is 12, as in *P. mediavus*. Length of fourth premolar, M. .0055; elevation of same, .0040; depth of ramus at P.-m. iv, .0057.

This species is known only from the material described above, and except for its small size is not well characterized. It represents a much smaller species than *P. mediavus*.

#### PTILODUS PLICATUS (Cope).

*Chirox plicatus* COPE, Proc. Amer. Phil. Soc., XXI, 1884, p. 321.

*Type-specimen.*—A series of three upper premolars,  $p^1$  to  $p^3$ . (No. 3032, Amer. Mus. Nat. Hist. Coll.)

*Neotype.*—The palate portion of the skull, containing the premolars and the first true molar of the right side, and premolars 1, 2,

<sup>a</sup> Measurements for  $m_2$  are taken from Cope's figure, Tertiary Vertebrata, Rept. U. S. Geol. Surv. Terr., 1884, pl. xxiii d, fig. 1b. For other measurements, see Cope, Amer. Naturalist, 1884, p. 694.



and 4 of the left side. (No. 3033, Amer. Mus. Nat. Hist. Coll.) A canine and incisor are represented by their fangs.<sup>a</sup>

*Type-locality*.—Northern New Mexico.

*Horizon*.—Torrejon formation.

The description, as given by Cope, is as follows:

*Char. gen.*: These are known from three superior molars; viz; the last premolar and the second and third true molars.<sup>b</sup> The fourth premolar has two external, and one internal cusps, and the true molars have four cusps each. \* \* \* The second true molar resembles a convex body which has been divided by two cuts at right angles to each other, from which the quarters thus produced have spread away from each other subequally. The external faces of the cusps are convex.

*Measurements* (after Cope).

	M.
Diameters of P.-m. iv [pm <sup>1</sup> ]	
{ anteroposterior-----	.0030
{ transverse-----	.0038
Diameters of m. ii [pm <sup>2</sup> ]	
{ anteroposterior-----	.0033
{ transverse-----	.0035
Diameters of m. iii [pm <sup>3</sup> ]	
{ anteroposterior-----	.0035
{ transverse-----	.0030

The description of the Neotype, as given by Cope, is as follows:

This genus was described by the writer in 1883, from a few teeth of the upper jaw found in the Puerco [*Torrejon*] formation of New Mexico. Since then a palate with the entire molar series of one side and nearly all that of the other has been obtained. This shows that the teeth described are premolars, and that there are two true molars, which resemble those of *Polymastodon* and *Neoplagiaulax*. The premolars are a good deal like those of *Plagiaulax*, as described to me by Professor Osborn, and the question arises whether the dentition in question does not belong to *Ptilodus*. There are two reasons for answering this question in the negative. First, in *Plagiaulax* and *Neoplagiaulax*, according to Osborn and Lemoine, there is a tooth in the superior series resembling and opposing the peculiar-cutting fourth premolar of the inferior series; second, the only tooth which could oppose such an inferior premolar is the first molar, and this is not worn obliquely, as in *Plagiaulacide*, but transversely, as in *Polymastodon*. This and the second true molar support two and parts of a third longitudinal rows of cusps, which are, on the last tooth, worn by anteroposterior movement of an inferior tooth of corresponding form.

As previously mentioned, the genus *Chirox* is now known to have been founded on the upper dentition of *Ptilodus*. The species, however, is probably distinct from *P. mediavrus*, apparently representing a larger form.

*PTILODUS MONTANUS* Douglass.

*Ptilodus montanus* DOUGLASS, Annals of the Carnegie Museum, V, No. 1, October, 1908, pp. 11 to 26, pls. x and xi.

*Type-specimen*.—A portion of the left lower jaw, containing the first molar and the last premolar. (No. 1673, Carnegie Museum Catalogue of Vertebrate Fossils.)

<sup>a</sup> Cope, Amer. Naturalist, XXI, 1887, p. 566.

<sup>b</sup> These are all premolars, as afterwards recognized by Cope.

*Type-locality*.—Sweet Grass County, Montana.

*Horizon*.—Fort Union formation.

The description as given by Douglass is as follows:

Crown of  $p_4$  semi-elliptical in a lateral view; crown not high, and upper portion of cutting edge not extremely convex; eleven distinct and two posterior indistinct ridges on the crown;  $m_1$  nearly one-half the length of  $p_4$ , with four external <sup>a</sup> and six internal <sup>a</sup> tubercles; anterior portion of tooth narrower than posterior portion.

The last premolar is larger than that of *Ptilodus trouessartianus* Cope, but not so large as that of *P. mediævus* Cope.

*Measurements of type* (after Douglass).

	mm.
Length of $p_4$ -----	7.5 [7.8] <sup>b</sup>
Length of $m_1$ -----	3.7 [3.4]

This is the first species of *Ptilodus* described from the Montana Fort Union and is apparently quite distinct from the New Mexico Torrejon species described by Cope. In the National Museum collection there are portions of upper and lower jaws representing four individuals that are probably referable to this species. They are two left lower-jaw fragments, each containing  $p_4$ ; a lower-jaw fragment containing  $p_4$  and  $m_1$ ; and an upper-jaw fragment containing the three anterior premolars. These are, respectively, Nos. 6077, 6078, 6079, and 6080, U. S. National Museum collection. They are from the same locality and horizon as the type of *P. montanus*.

**PTILODUS GRACILIS, new species.**

*Type-specimen*.—A partial skeleton, including a nearly complete skull and lower jaws, the greater portion of the pelvis, one femur, the distal portion of the humerus, a radius and portion of an ulna, the proximal end of a tibia, a terminal phalanx, portions of vertebrae, and other fragments. (Cat. No. 6076, U.S.N.M.)

*Type-locality*.—Sweet Grass County, Montana.

*Horizon*.—Fort Union formation.<sup>c</sup>

*General definition*.—Dental formula,  $i_1^1, c_1^1, pm_4^{\frac{1}{2}}, m_3^2$ . In size this species is about intermediate between *P. mediævus* and *P. trouessartianus*. It is but slightly smaller than *P. montanus* Douglass. The lower jaw is far more slender in proportions than either *P. mediævus* or *P. montanus*; the fourth premolar is relatively higher and has 14 ridges on either side of the crown. Lower  $m_1$  has but 5 tubercles in

<sup>a</sup> This is evidently a typographical error and should read "four internal and six external tubercles."

<sup>b</sup> In carefully remeasuring the type I find these measurements to be: Length of  $p_4$ , 7.8 mm.; length of  $m_1$ , 3.4 mm.

<sup>c</sup> Other forms from these beds indicate that this horizon is about equivalent to, as reported by Douglass, or perhaps somewhat older than the Torrejon beds of New Mexico.

the outer row of cusps, as compared with 6 in *P. montanus*. The upper dentition of this species can at present be compared only with that of *Ptilodus plicatus* Cope, since the upper molariform teeth of other species of the genus are not known. The principal differences thus shown are: (1) The smaller proportions of *P. gracilis*, which is about one-fourth less in size; (2) the proportionately greater antero-posterior length of the cheek teeth; and (3) the greater number of cusps in  $p^3$ , there being 6 cusps instead of 5, as in the type, or 4, as in the neotype of *P. plicatus*. The number of these cusps may be more or less variable, but are probably of specific importance.

#### DETAILED DESCRIPTION.

*The dentition.*—The teeth of the present specimen being fully adult and but little worn afford an excellent opportunity both for a detailed and general study of their characters.

The single upper incisor preserved is placed in the premaxillary near but not closely appressed to the median line. It is a relatively long, rounded and gently curved tooth, with a pointed tip. The crown is slightly compressed on the posterior face with lateral angles dividing the surface into two unequal areas, the posterior one being the smaller and less convex. Near the summit of the tooth the posterior area is subdivided obliquely by a sharp ridge running from the apex upward and outward to the outer main angle, so that the tip of the crown is roughly triangular in cross section.

The next tooth in the upper series, which from its position is apparently a canine, is separated from the incisor just described by a considerable diastema. It much resembles the incisor in general form, but is smaller, and a posterior oblique ridge runs to the inner main angle instead of the outer one. A considerable diastema separates the canine from the premolar series.

The first upper premolar,  $p^1$ , is a triangular tooth composed of three nearly equal subpyramidal cusps whose apexes point slightly backward. Premolar<sup>2</sup> resembles  $p^1$ , except that it is quadrate in outline and has four subequal cusps. This tooth is somewhat higher crowned than the others and is the largest of the anterior three premolars. Premolar<sup>3</sup> equals  $p^2$  in length, but is narrower and less robust. The crown is quadrangular and bears six cusps of nearly uniform size arranged in two longitudinal rows. The anterior pair is somewhat smaller than the others, and the cusps are closely joined to those of the median pair. This tooth strikingly resembles the upper true molars of *Plagiaulax* (*Bolodon*). All the cusps of the anterior premolars have the peculiar wrinkled appearance noted by Cope, Marsh, and others.

In classing the next tooth of the upper series with the premolars. I differ from the opinions of Cope and Osborn, who called the cor-



responding tooth in *Ptilodus plicatus* the anterior true molar. However, a critical examination shows that, though resembling in general form the molar next behind it, it differs from that tooth in several important particulars, while in position and function it properly belongs with the antemolar series. Like the first true molar,  $p^1$  is much elongated anteroposteriorly and is multituberculate, but here the real resemblances between the two teeth end.  $P^1$  is made up of two rows of cusps of unequal length, the inner, composed of nine tubercles of nearly uniform size, being the longer, while the tubercles of the outer row, seven in number, are very unequal, some being larger and some smaller than those of the inner row. The third tubercle from the front in the outer row is the largest and principal cusp of the tooth; in consequence the transverse diameter of the crown is greatest at this point. This and the three other larger cusps of the outer row have the characteristic wrinkling of the enamel seen in the anterior premolars and is almost a duplicate of the outer main cusps of  $p^2$ ; if detached, it might readily be mistaken for one of them. There is a marked difference in the character of these cusps and the smooth-surfaced tubercles of the true molars.

In contrast with  $p^1$ ,  $m^1$  is composed of two subequal rows of tubercles of nearly uniform size and a third less prominent and much shorter inner row, which, in the present specimen and in *P. plicatus*, is developed only along the posterior half of the crown; thus the widest transverse diameter of this tooth is at the extreme posterior end instead of across the anterior half, as in  $p^1$ . The last tooth of the series,  $m^2$ , is wider transversely, but is much shorter than  $m^1$ . It has three rows of tubercles, the inner and outer rows being fused into an almost undivided ridge. The cusps of the median row are slightly curved and point forward.

The lower incisors are comparatively long, slender, and moderately curved. They are oval in section at the base, but are somewhat flattened on the inner faces and are sublanceolate near the tips. A considerable portion of the tip is completely enamel-covered, although the enamel is thin on the posterior face and it does not continue to the base of the crown. When placed in their normal position the lower incisors come in contact with each other only along the sharp angles forming the anterior borders of their inner faces.

The lower premolars are reduced to two in number and are greatly specialized,  $p_2$  being vestigial, while  $p_1$  is the largest and most highly modified tooth of the lower series. It is set obliquely in the jaw, so that its fore-and-aft plane comes in direct line with the cheek-tooth row and parallel to that of its fellow of the opposite side; its normal position is well shown in Plate 70, fig. *c*. The tooth crown dips downward at a sharp angle anteriorly, so that its highest point is on a level with the low-crowned molars. This position brings the grooves



and ridges of its sides at right angles to the horizontal plane of the tooth row, and consequently in line with the direction of force brought to bear on the tooth in normal use. This position of the tooth in the jaw would explain the relatively large size of the anterior fang, which much exceeds the posterior one, since much the greater part of the strain would thus be transmitted to that portion of the tooth. It probably also accounts for the uniform persistence of the vestigial  $p_3$ , as the latter is placed well under the anterior edge of  $p_4$  in such a position as to receive part of the strain imparted to  $p_4$ . Thus  $p_3$  evidently served as a prop or supplementary buttress for the large cutting tooth.

The combined length of the two lower molars is somewhat less than that of the upper true molars which they directly oppose; but this discrepancy in length is compensated by the peculiar fore-and-aft movement of the jaw in chewing. Both molars are low-crowned, with two rows of subequal tubercles.  $M_1$  has 5 cusps in the outer and 4 in the inner row, while  $m_2$  has 3 in the outer and 2 in the inner row.  $M_2$  is broader and shorter than  $m_1$ .

The *skull* is relatively short and broad, its greatest width being across the posterior ends of the zygomatic arches. The zygomatic arch is moderately slender. It joins the maxillary opposite the anterior half of  $p^1$  and extends backward nearly to the lambdoidal crest. The malar extends backward to the glenoid surface, and apparently joins the lachrymal bone anteriorly as in the living marsupials. The anterior extension of the malar, however, can not be made out with certainty, owing to the almost complete obliteration of suture lines in this region. The occiput extends but slightly beyond the posterior root of the zygoma; this, with the extreme backward extension of the cheek-teeth series, gives the basi-cranial region very short and broad proportions. The brain case is large, but comparatively smaller than that of living marsupials, and is marked anteriorly by a distinct but broad constriction of the skull. The nasals are relatively large and broad, expanding posteriorly. They join the frontals on a line slightly forward of the anterior margin of the orbits. The maxillaries are relatively very large and deep, and extend well backward to accommodate the long row of cheek teeth. The premaxillaries are short and widely separated from the frontals by the ascending portion of the maxillary. The relatively broad, high-arched palate is perforated by two pairs of foramina. The posterior pair are very large, occupying nearly one-half the entire length of the palate. The palate back of the muzzle is narrowest between the last pair of molars and widest between the third pair of premolars. The characters of the basicranial region can not be made out clearly, owing to crushing and breaking, but there appears to be an alisphenoid canal and a well-developed alisphenoid bulla.

The glenoid fossæ are broad, nearly flat, and extend well forward, giving free fore and aft movement to the lower jaws. The right occipital condyle is broken away, but the remaining one is broad and shows that the pair were set widely apart; the articular surface curves gently outward, backward, and upward. There is a distinct notch on the inferior inner border of the condyle, a character also observed in some of the living diprotodont marsupials.



FIG. 1.—LEFT HUMERUS OF PTILODUS GRACILIS. TYPE. ANTERIOR VIEW. TWICE NAT. SIZE.

A nearly complete cervical, probably the sixth or seventh, and parts of two or three broken caudals are practically all the elements preserved representing the *vertebral column*. The cervical vertebra is slightly longer than broad, indicating a moderately long neck. The caudals are relatively large, with well-developed processes, indicating a long and rather heavy tail.

The *humerus* (see fig. 1) is incomplete, but the head, the distal end, and a considerable portion of the shaft are preserved. These portions show some important characters. It is distinctly eutherian throughout, and is very unlike that of any of the living Montremes. The head is relatively large, broadly oval in outline, and well rounded. The shaft is moderately long and slender, with well-developed but not highly specialized deltoid ridge. The distal end is moderately expanded, and the articular surface is divided into two well-defined ridges, the inner, or trochlea, being somewhat broader, especially on the anterior face, than the outer, or capitellum. The inner condyle occupies about one-third of the transverse diameter of the distal end of the humerus. The entepicondylar foramen is small, broadly oval in outline, and placed close to the trochlea. The olecranal fossa is deep and sharply defined.

The *radius* (see fig. 2) lacks the distal epiphysis, but is otherwise complete. The shaft is comparatively long and slender, slightly curved, and nearly round in cross section. The tuberosity for the attachment of the biceps muscle is well developed. The head is expanded into a broadly elliptical, almost circular disk, with a wide transversely convex facet for the articulation of the ulna. Its form indicates a perfectly free rotation of the forearm. Another long slender bone lacking the epiphysis of the distal end, and with the proximal end somewhat broken, represents the ulna.



FIG. 2.—RIGHT RADIUS OF PTILODUS GRACILIS. TYPE. *a*, VIEW OF PROXIMAL END; *b*, SIDE VIEW. TWICE NAT. SIZE.

The feet are represented by an ungual phalanx (fig. 3) and two or three portions of metapodials. These bones, which from their relatively small size apparently belong to the fore feet, are rather long and slender in proportions and not specialized. The ungual phalanx apparently supported a rather sharp claw.

The *pelvis* is proportionately large but primitive in structure. (See fig. 4.) The ilium is a long, slender, rod-like bone, somewhat flattened transversely. The ischium is moderately long and expanded.

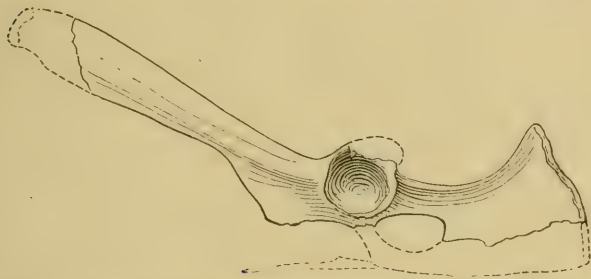


FIG. 4.—LEFT HALF OF PELVIS OF *PTILODUS GRACILIS*. TYPE. OUTER VIEW. TWICE NAT. SIZE.

Unfortunately the greater part of the pubis is broken away so that the presence or absence of marsupial bones can not be determined, although they probably were present. The obturator foramen, as indicated by its upper border, which is preserved, is comparatively small.



FIG. 5.—RIGHT FEMUR OF *PTILODUS GRACILIS*. TYPE. POSTERIOR VIEW. TWICE NAT. SIZE.

The *femur* (see fig. 5) is relatively large and stout as compared with the humerus. Both trochanters are well developed, the great trochanter extending considerably above the head of the femur. The lesser trochanter is a prominent tubercle, and is situated on the posterior face of the shaft near the base of the great trochanter as in the eutherian mammals. The shaft is nearly straight and is slightly flattened anteroposteriorly.

The *tibia* and *fibula* (see fig. 6) are poorly preserved, but are represented by portions of the proximal ends. The tibia is much the larger bone. Both are large as compared with the radius and ulna. The relatively large proportions of

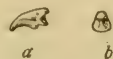


FIG. 3.—TERMINAL PHALANX OF *PTILODUS GRACILIS*. TYPE. *a*, SIDE VIEW; *b*, PROXIMAL END VIEW. TWICE NAT. SIZE.

the pelvis and hind limbs strongly suggest that *Ptilodus* was saltatorial in habits.



FIG. 6.—PROXIMAL PORTIONS OF TIBIA AND FIBULA OF *PTILODUS GRACILIS*. TYPE. POSTERIOR OBLIQUE VIEW. TWICE NAT. SIZE.

## Measurements of type.

[Dimensions in millimeters.]

	Anteroposterior.	Transverse.
Diameters of $p^1$ -----	2.5	2.1
Diameters of $p^2$ -----	2.5	2.5
Diameters of $p^3$ -----	3	2
Diameters of $p^4$ -----	5	2.5
Diameters of $m^1$ -----	4.6	2.1
Diameters of $m^2$ -----	2	2.3
Total length of upper dental series-----		25
Length of molar-premolar series-----		19.5

	Anteroposterior.	Transverse.	Height.
Diameters of lower $p_1$ -----	7.6	2.4	5.6
Diameters of lower $m_1$ -----	3.3	1.8	1
Diameters of lower $m_2$ -----	2.4	2	---
Total length of lower series, including incisor-----			20.8
Length of molar-premolar series-----			12.2
Length of lower jaw-----			26
Length of lower jaw, including incisor-----			31
Depth of lower jaw at $m_1$ -----			6.8
Depth of lower jaw at $p_1$ -----			5.5
Total length of skull-----			41
Greatest width of skull (across glenoid fossæ)-----			31.6
Width of skull at $p^4$ -----			15.5
Width of palate between first premolars-----			8
Width of palate between last molars-----			8
Width of palate between fourth premolars-----			11
Distance from occipital condyle to posterior border of palate-----			15
Transverse diameter of occipital condyles-----			9.2
Distance from center of glenoid fossa to $m^2$ -----			11
Distance from condyle of lower jaw to $m_2$ -----			11
Length of humerus (estimated)-----			24
Length of distal portion preserved-----			16
Greatest diameter of head of humerus-----			4.9
Transverse diameter of shaft-----			2.6
Width across condyles-----			5.6
Width across articular surface (anterior)-----			3.4
Width across articular surface (posterior)-----			2.6
Anteroposterior diameter of trochlea-----			3.4
Total length of pelvis (estimated)-----			37
Length of ischium-----			12.5
Diameter of acetabulum-----			3.8
Length of femur-----			32+
Diameter of shaft-----			4

PTILODUS SERRATUS? <sup>a</sup> (Marsh).

A left lower fourth premolar (Cat. No. 6088, U.S.N.M.), found in the same deposits from which the types of *P. montanus* and *P.*

<sup>a</sup> *Halodon serratus* Marsh, Amer. Journ. Sci., XXXVIII, 1889, p. 87, pl. III, fig. 14.



*gracilis* were obtained, represents a third and much smaller species of *Ptilodus* from these beds. This tooth is about the size of the type of *P. Trouessarti* Cope, but does not agree with it in proportions, the latter being relatively much lower crowned. In this respect it corresponds much more closely and agrees also in size with the type of "*Halodon serratus*" Marsh, from the Ceratops beds of Converse County, Wyoming. For the present I provisionally refer it to Marsh's species, although there are minor differences which indicate that it may later be placed in a new species.

• **PTILODUS FORMOSUS? <sup>a</sup> (Marsh).**

A fourth and still smaller species is represented in this collection from the Fort Union by two lower fourth premolars (Cat. Nos. 6089 and 6090, U.S.N.M.). These teeth, which are only 3.2 mm. in length, agree in size, proportions, and the number (12) of enamel ridges with Marsh's "*Halodon formosus*," from which they can not at present be distinguished. The type of this species is also from the Ceratops beds.

**ZOOLOGICAL RELATIONS.**

Owing to the absence of good material, well-defined characters other than those presented in the teeth have hitherto been wanting. In consequence there has been a wide diversity of opinions regarding the relation of the Multituberculates to other great groups of the Mammalia. Earlier writers, studying Jurassic forms, classed them with the *Marsupialia*. Marsh, in 1880,<sup>b</sup> first proposed placing the group in a distinct order, which he named the *Allotheria*, although recognizing their marsupial affinities. In defining the order he said:<sup>a</sup> "These characters alone do not indeed separate the *Plagiaulacidae* from some of the Marsupials, and future discoveries may prove them to belong in that group, where they would then represent a well-marked suborder." Later Cope<sup>c</sup> proposed the name *Multituberculata* for this same group, which he considered a suborder of the *Marsupialia*. Still later he suggested their relationship to the Monotremes. At present most authorities rank the group as a full order, which is variously classed with the Marsupials or the Monotremes.

As has been stated by Osborn,<sup>d</sup> the relationship of the group to the Marsupialia, which was first proposed by Falconer, had not been questioned until the discovery, by Poulton, of the early-shed multitubercular teeth of *Ornithorhynchus*. This led Cope to suggest the reference of the Multituberculates to the *Monotremata*, a view which

<sup>a</sup> *Halodon formosus* Marsh, Amer. Journ. Sci., XXXVIII, 1889, p. 179, pl. VIII, fig. 36.

<sup>b</sup> Amer. Jour. Sci., (3) XX, 1880, p. 239.

<sup>c</sup> Amer. Naturalist, XVIII, 1884, p. 687.

<sup>d</sup> The Structure and Classification of the Mesozoic Mammalia, Journ. Acad. Nat. Sci., Phila., (2), IX, 1888, p. 254.

has found rather wide acceptance. In his classification of the Mesozoic Mammals<sup>a</sup> Osborn stated his own views as follows:

While the Multituberculata are widely separated from the mammals of the second group [including the Trituberculate forms] they are so closely related to each other by the unique structural and functional adaptations of the dentition, that the discovery in one genus of a single taxonomic character, which is distinctive, will probably determine their position either with the Monotremata or Marsupialia or in an independent order; \* \* \*.

The separation of these genera from the Diprotodonts justifies the prediction, as a result of future discovery, that the Multituberculata will prove to be the last representative of a very ancient phylum which reached too great a degree of specialization and dental reduction at the close of the Cretaceous to survive or leave descendents in the recent period. Whether they are to be considered as a branch of the monotreme or of the marsupial stock is an unsettled question.



FIG. 7.—RIGHT LOWER JAW OF *TRICHOSURUS VULPECULA* KERR. CAT. NO. 85436, U. S. N. M. INNER VIEW.  $\frac{1}{2}$  NAT. SIZE.

In his latest classification of the Mammalia,<sup>b</sup> Osborn lists the Allotheria under the subclass *Protheria* as a doubtful order of uncertain systematic position.

Falconer and Owen referred *Plagiaulax* to the Diprotodontia, but differed in their opinions regarding its probable habits and taxonomic relations. Falconer compared *Plagiaulax* with *Hypsiprymnus* (*Potorous*) and sought to prove that the former was a salutory herbivorous marsupial, allied to the Rat-Kangaroos. Owen<sup>c</sup> just as strongly contended that it was carnivorous in habits, and more probably related to the extinct carnivorous *Thylacoleo*.

Owen's conclusions regarding the carnivorous habits of *Plagiaulax* lose much of their force since it is now apparent, through a study of the present specimen of *Ptilodus*, that his principal arguments were based on an error in the interpretation of a most important factor, namely, the normal position of the jaw. Viewing the lower jaw of *Ptilodus*, properly articulated with the upper (see figs. 7 and 8), it is observed that passing forward it pitches downward at a considerable angle, bringing the plane of the tooth-row below the condyle, and the incisors into a semiprocumbant position as in the Diprotodonts. It will be noted also that the greater part of the thin cutting blade of *p*<sub>1</sub> does not come in contact with the upper teeth, but stands free in the mouth. If the lower jaw of *Plagiaulax* is thus placed



FIG. 8.—RIGHT LOWER JAW OF *PTILODUS GRACILIS*. TYPE. INNER VIEW.  $\frac{1}{3}$  NAT. SIZE.

<sup>a</sup> Journ. Acad. Nat. Sci. Phila. (2), IX, 1888, p. 254.

<sup>b</sup> Evolution of the Mammalian Molar Teeth, 1907, p. 11.

<sup>c</sup> Fossil Mammalia of the Mesozoic Formations, 1871.

(see fig. 9), here also the condyle is above the tooth-row and not below it, as stated by both Owen and Falconer. The premolar teeth likewise drop away from the level of the molar series, forward, so that the anterior ones could scarcely have come in contact with any teeth of the upper jaw. It is further observed that, as in *Ptilodus*, the ridges on the sides of the cutting blades viewed laterally run nearly at right angles to the plane of the molars; thus these ridges which have always been described as being "oblique" in the fossil forms, are after all placed in the same relative position in the mouth as those of the ridged premolars of living species. Assuming this position for the lower jaw and recognizing the fact that the blade-like premolars did not oppose teeth of like structure in the upper jaw, the carnivorous characters pointed out by Owen seem to disappear, while the general resemblances to the less specialized Diprotodonts become more than ever apparent.

The resemblances pointed out by Falconer<sup>a</sup> between *Plagiaulax* and *Potorous* ("Hypsiprymnus") a genus of the Macropodidæ, are in the main substantiated in the present specimen of *Ptilodus*, which also possesses some important characters in common with some of the Phalangeridæ, as *Trichosurus* and *Phalanger*. The specialization of the teeth, however, has been carried to a greater degree, both in reduction in numbers of the molars and in the development of the premolars, than in any of the living Diprotodonts.

This preliminary study leads apparently to the following conclusions regarding the zoological position not only of *Ptilodus* and the Plagiaulacidæ, but of the Allotheria in general. A fact of first importance is that neither in the skull nor skeleton of the Montana specimen are there any indications of affinities suggesting the Monotremes, while every character is marsupial, as shown in the general arrangement and function of the teeth and the development of the skull and skeleton. The unequal development of the fore and hind limbs, the character of the incisors, the form of the palate, and the position of the cheek-teeth all indicate definite affinities with the Diprotodonts. At the same time the reduction in numbers of the molars and the extreme specialization of the premolars confirms Osborn's conclusion regarding the philetic position of the group, namely, that the Multituberculata may be the last representatives of a very ancient phylum that became extinct in the early Tertiary.

From the foregoing therefore it appears that the Allotheria represent an extinct group of multituberculate eutherian mammals closely



FIG. 9.—RIGHT LOWER JAW OF *PLAGIAULAX BECKLESII* FALCONER. INNER VIEW. ABOUT NAT. SIZE.

<sup>a</sup> Quart. Journ. Geol. Soci. London, XIII, 1857.



related with but not ancestral to the Diprotodont division of the Marsupialia, with which division they may be now classed as an Infraorder, or Superfamily, their relationship dating back to a common ancestry somewhere in the Jurassic or even to earlier Triassic times, as was suggested by Cope.

Regarding the probable character of the food, upon which *Ptilodus* and its related genera subsisted, the specimen from Montana described above seems to throw considerable light. An examination of the type of *P. gracilis* (Pl. 70) shows Cope's<sup>a</sup> statement, that the grinding teeth are "weak in structure," is incorrect, and his supposition that it was necessary for the animal to swallow its food without mastication is not admissible. On the contrary it will be seen that the grinding area is comparatively very considerable, occupying nearly three-fourths of the actual contact space between the upper and lower dental series, and although the tooth-crowns are low they are relatively broad and massive. To add to their efficiency the molars are well supplied with an array of short stout tubercles, well adapted to crushing and grinding small hard substances but very poorly adapted to cutting or masticating meat. In specimens of old individuals the much worn condition of the tubercles of the molars as compared with that of the lower cutting-premolar suggests that the latter may have been used for the purpose of cutting only soft materials, such as the skin and pulp of fruit, while the molars were employed in grinding harder substances, such as seeds.

The evidence that *Ptilodus* and *Plagiaulax* were not carnivorous in habits seems rather conclusive, but as to whether they were insectivorous, herbivorous, or frugivorous there may still be some differences of opinion. I am inclined to consider them as frugivorous, since the incisors were well fitted for picking small fruits or berries, while the large cutting blades of the lower premolars were admirably adapted to cutting or slicing the rinds of tough-skinned berries, or to chopping up fleshy fruits held against the blunt-pointed premolars of the upper jaw. For masticating the seeds of such small fruits and berries the multituberculate molars were amply sufficient.

#### EXPLANATION OF PLATE 70.

##### *Ptilodus gracilis* Gidley.

(Type-specimen.—Cat. No. 6076, U.S.N.M. All figures twice natural size.)

Fig. a. Skull with lower jaw in position, side view.

b. Right ramus of lower jaw, inside view.

c. Lower jaws in normal position, viewed from above.

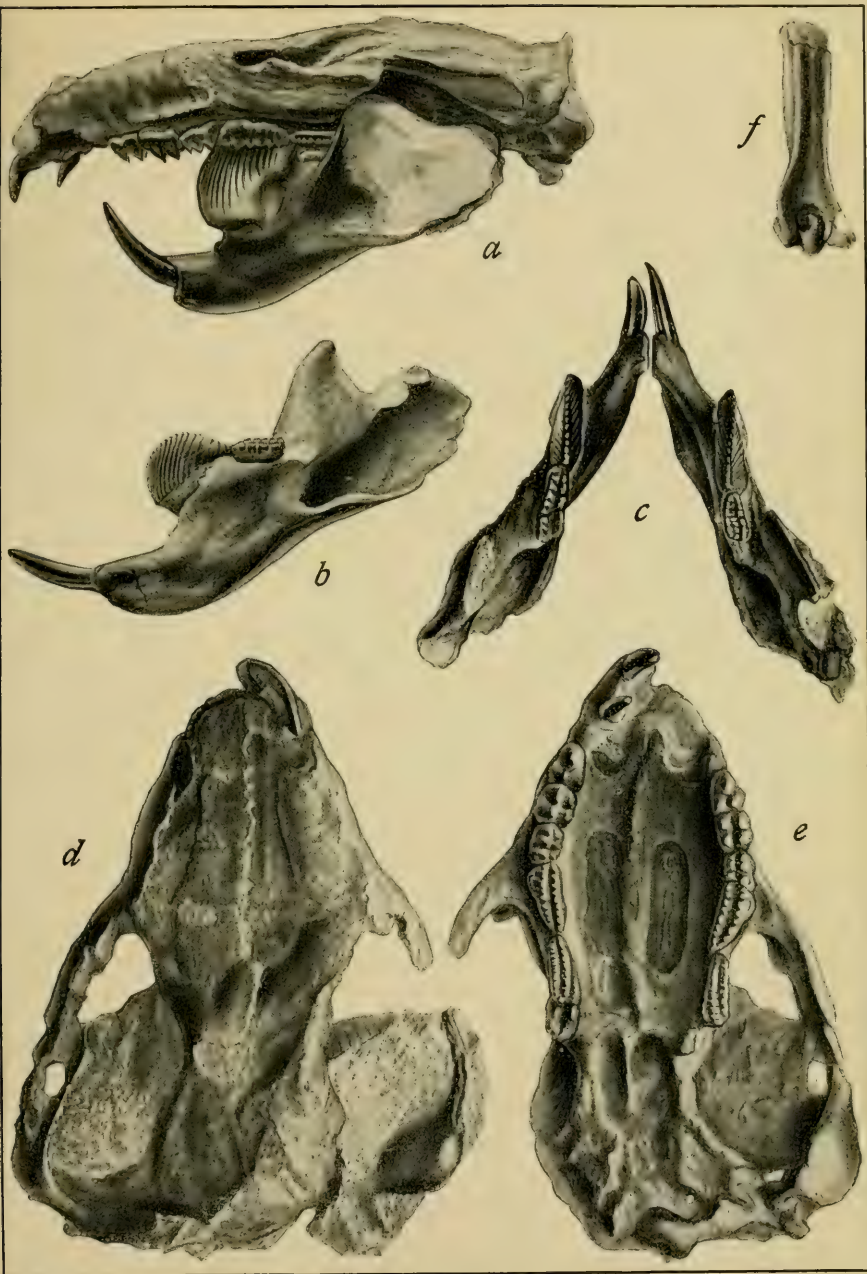
d. Skull, top view.

e. Skull, palate view.

f. Distal portion of left humerus, posterior view.

<sup>a</sup> Cope, Tertiary Vertebrata, U. S. Geol. Surv. Terr., III, 1884, p. 170.





PTILODUS GRACILIS GIDLEY.

FOR EXPLANATION OF PLATE SEE PAGE 626.



# FRESH-WATER SPONGES IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM.—PART I. SPECIMENS FROM THE PHILIPPINES AND AUSTRALIA.

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By NELSON ANNANDALE,  
*Superintendent of the Indian Museum, Calcutta.*

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The collection of Spongillinae in the United States National Museum consists very largely of specimens named by Mr. Edward Potts, whose Monograph of the Fresh-water Sponges<sup>a</sup> must ever remain a classical work on the group. Since Mr. Potts gave up active work on the sponges, however, a considerable number of specimens have been added, which the authorities of the Smithsonian Institution have been kind enough to send me for examination. As these specimens are accompanied by duplicates of all the named American species in the collection, and as the Indian Museum possesses an almost complete set of the species recorded from Europe, Asia, and Africa, I hope that it may ultimately be possible for me to determine all those that are determinable. In the meanwhile, stress of official work renders it difficult for me to attack the American species, and I propose, therefore, to deal separately with those from the Philippines and Australia.

## Genus SPONGILLA.

### Subgenus EUSPONGILLA Vejdovsky.

#### SPONGILLA SCEPTRIOIDES Haswell.

*Spongilla sceptrioides* HASWELL, Proc. Linn. Soc. N. S. Wales, 1882, p. 209.—v. LENDENFELD, Zool. Jahrbücher, II, 1887, p. 89.

Haswell's original description is very brief, and Lendenfeld adds little of importance to it. There is a specimen in the collection under review which is labeled, "Fresh water Sponge with winter eggs Queensland, Australia Apr. 4—". This, I believe, to represent Haswell's species, although I have had some doubts as to the identity. It will be well, therefore, to describe the specimen in some detail.

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<sup>a</sup>Academy of Natural Sciences, Philadelphia, 1887.

It apparently formed an irregular mass some 10.5 cm. long and 2 cm. thick, coating a piece of stick, but has unfortunately been much damaged in transit and now consists for the most part of loose powder and gemmules. The color (dry) is a pale gray. The surface so far as it remains, is smooth, with fairly large oscula (about 3 mm. in diameter), which are not raised on eminences. The external membrane has wholly perished. The substance of the sponge is com-

pact, the primary radiating fibers, but not the secondary transverse ones, being visible in a vertical section to the naked eye as slender white threads. The gemmules, which are practically colorless, are numerous throughout the sponge.

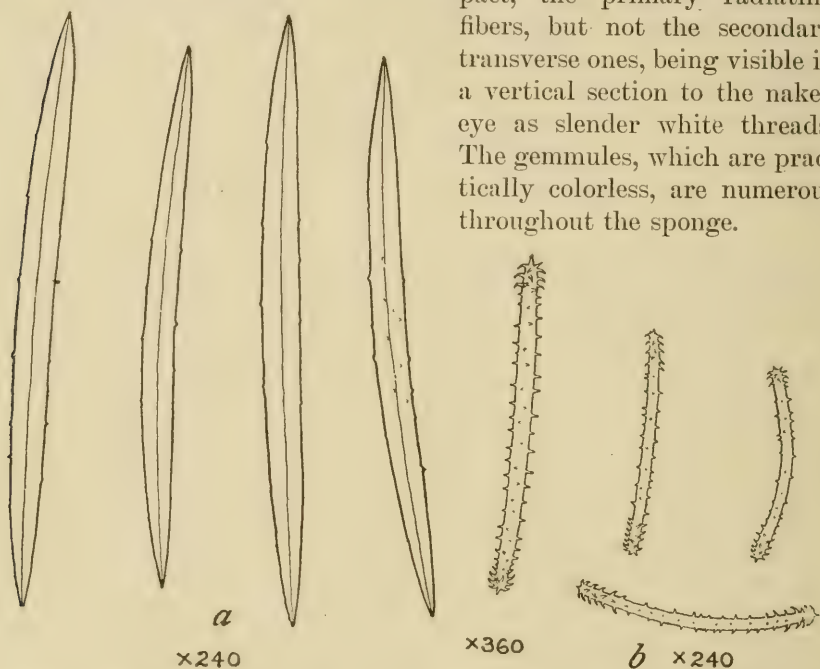


FIG. 1.—SPONGILLA SCEPTRIOIDES. *a*, SKELETON SPICULES; *b*, GEMMULE SPICULES.

The largest skeleton spicules measure 0.35 mm. by 0.021 mm. They are straight or feebly curved and are covered with extremely minute projections in the central part of their length, the ends, which are sharply and cleanly pointed, being smooth. The projections are so minute that it is often difficult to see them. They are conical in outline, somewhat broad at the base in comparison with their length, and are rarely sufficiently numerous to give the spicules a roughened look under a low power of the microscope.

I can find no flesh spicules.

The gemmule spicules measure from 0.126 mm. to 0.147 mm. in length. They are slender in proportion (transverse diameter about 0.0042 mm.) and straight or feebly curved. The spines which cover them with fair uniformity are about half as long as the spicule is thick; those in the middle are straight, those at either end curved and directed backward. As a rule the spicule terminates at either end in a single straight spine.



In general structure the gemmules closely resemble those of *Spongilla lacustris*. They are spherical and measure on an average 0.52 mm. in diameter. There is a thick granular coat, in which the spicules are arranged close together and tangentially, while an outer layer of horizontal spicules can be detected on the surface of some gemmules. The aperture of the gemmule, which is single, is provided with a stout foraminal tubule, which is generally more or less curved and projects through the granular coat.

*Remarks.*—It is clear that this sponge is a close ally of *S. lacustris*, from which it may be distinguished by the absence of free spicules and by the armature of the aperture of the gemmule. From my *Spongilla proliferens* it is distinguished by its more compact and massive structure as well as its lack of free spicules.

*Spongilla sceptrioides* has been recorded from New South Wales and Queensland.

SPONGILLA PHILIPPINENSIS, new species.

The sponge has evidently formed a sheet of considerable size adherent to some solid body but has been broken into small pieces in the

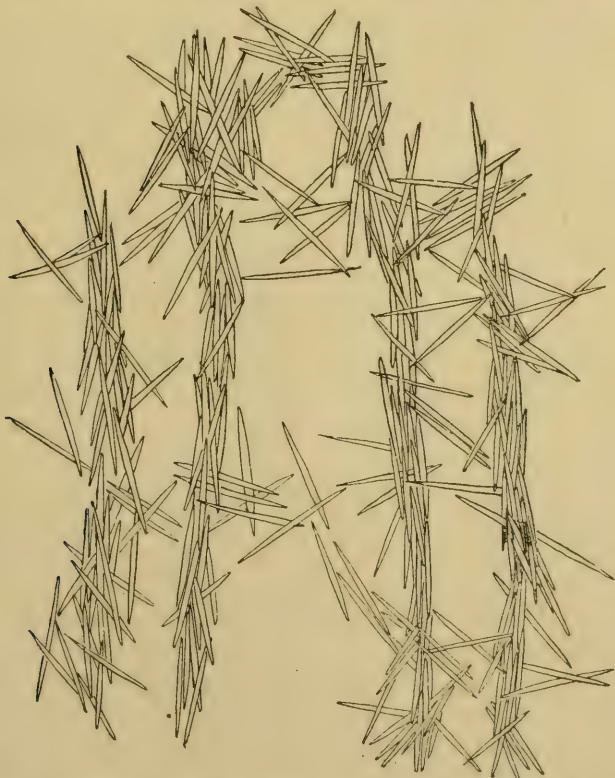


FIG. 2.—SPONGILLA PHILIPPINENSIS, FRAGMENT OF SKELETON,  $\times 70$ .

type-specimens, which are about 1 cm. thick. The surface is smooth, with numerous oscula level with it. There is no trace of branches.

Externally the sponge appears to have been bright green in color, but the basal parts are yellowish. The texture is light and friable, by no means elastic.

In vertical section both radiating and transverse fibers are visible to the naked eye and the sponge has a distinctly reticulate appearance, although the vertical interspaces are much more conspicuous than the horizontal ones. Wide circular canals penetrate the sponge in a course parallel to its base. Comparatively little spongin is present. Under the microscope it is evident that the radiating fibers are much

more coherent and regular than the transverse ones. On the external surface of the sponge a network of horizontal spicules can be distinguished.

There is a delicate basal structureless membrane. The ectodermal membrane has perished.

The skeleton spicules measure 0.174 mm. to 0.278 mm. in length and on an average 0.021 mm. in greatest transverse diameter. They are very sharply pointed at both ends, straight or nearly so, smooth or somewhat sparsely covered with extremely minute projections, the ends being always smooth.

There are no flesh spicules.

The gemmule spicules are very variable in length, measuring from 0.0798 mm. to 0.122 mm. in length and about 0.0031 mm. in transverse diameter. They are cylindrical, straight or nearly so, armed with somewhat irregular spines, which are often slightly retroverted at the two ends. Sometimes there is a single straight spine at either end, but often the spicule ends abruptly and is surrounded by a ring of spines in such a way as to suggest a rudimentary rotule.

There are few gemmules, those that exist occurring singly in the substance of the sponge and being free. They have a blackish color, are spherical, measuring on an average 0.609 mm. in diameter. Each is provided with a single aperture, to which a short, straight, rather stout foraminal tubule is attached. The inner chitinous coat is

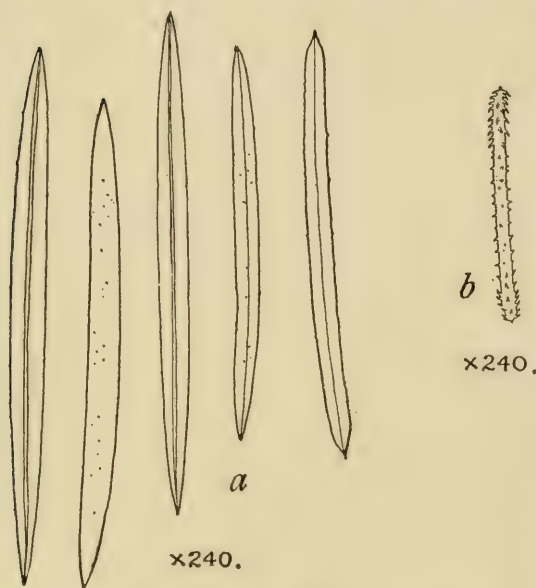


FIG. 3.—SPONGILLA PHILIPPINENSIS. a, SKELETON SPICULES; b, GEMMULE SPICULE.

rather thin, but the granular coat is well developed and contains many spicules, which are arranged horizontally or nearly so as a rule, but sometimes to a slight extent tangentially.

*Habitat*.—Camp Keithly, Lake Lanao, Mindanao, Philippines. Altitude 2,250 feet. Mary Strong Clemens, collector, January, 1907.

*Type-specimen*.—Cat. No. 7718, U.S.N.M.

*Remarks*.—With the exception of *Ephydatia fortis* from Luzon, this appears to be the first fresh-water sponge recorded from the Philippines. It appears to be quite distinct from the other form discovered with it and here described; but it is just possible that it may be a form of *S. sceptrioides*. Pending the acquisition of further information regarding the latter species, however, I prefer to consider it a new species.

All the specimens I have seen are dry.

Subgenus **STRATOSPONGILLA** Annandale.

**SPONGILLA CLEMENTIS**, new species.

In general appearance and color this sponge, judging from dry specimens, closely resembles *S. philippinensis*, but the surface is usually covered with a network of deep, broad furrows which separate small elevated areas of a more or less circular form. The oscula occur on these elevated areas and are large and numerous. Probably in the fresh sponge the furrows are roofed in by the ectodermal membrane.

In vertical section the transverse fibers of the skeleton are seen to be stouter and more regular than those of *S. philippinensis*, being hardly inferior to the radiating fibers in these respects, so that the skeleton forms a much more regular network than is the case in the other sponge.

There is a stout chitinous membrane, which sends bunches of hollow root-like processes downwards at intervals. These do not appear to be in any way connected with the primary skeleton fibers. There are numerous scattered skeleton spicules in the basal membrane.

The skeleton spicules are smooth, as a rule, but occasionally bear a few irregular spines; they are somewhat bluntly pointed at the ends, as a rule regularly but feebly curved. They measure on an average 0.252 mm. in length and 0.021 mm. in greatest transverse diameter.

There are no flesh spicules.

The gemmule spicules are slender, cylindrical, nearly straight. In the middle they bear minute irregular projections, which only take the form of actual spines towards the two ends. Each end terminates in a stout, straight spine, surrounded by a row of smaller spines at right angles to it. None of the spines are retroverted.

There are very few gemmules indeed. They occur singly in the basal membrane and are apparently closely adherent to the support



of the sponge. Each measures about 0.325 mm. in diameter (the shape being spherical) and is provided with a single straight for-  
aminal tubule on the summit. The granular coat is feebly developed,  
but there is a strong outer chiti-  
nous coat in continuity with the  
basal membrane. The gemmule  
spicules lie in this coat parallel  
or almost parallel to the surface  
of the gemmule but crossing one  
another at all angles.

*Habitat*.—Camp Keithly, Lake  
Lanao, Mindanao, Philippine Is-  
lands. Altitude 2,250 feet. Mary  
Strong Clemens, collector, Jan-  
uary, 1907.

*Type-specimen*.—Cat. No. 7719,  
U.S.N.M.

*Remarks*.—This sponge, which I  
have much pleasure in naming  
after its discoverer, is evidently

very distinct from  
*S. philippinensis*  
(with which it was  
apparently found  
in close associa-  
tion), differing in  
its shorter and  
smoother skeleton  
spicules, more reg-  
ular skeleton,  
thicker basal mem-  
brane, and adherent  
gemmules with  
their ill-developed  
granular coat. It  
approaches those  
forms I have re-  
cently grouped to-

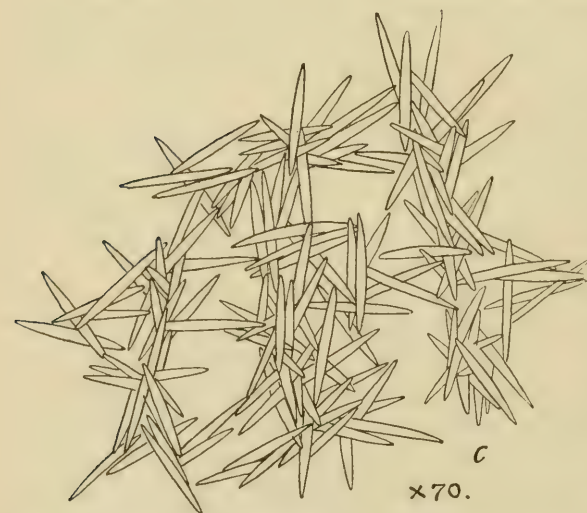


FIG. 4.—*SPONGILLA CLEMENTIS*. a, SKELETON SPICULES;  
b, GEMMULE SPICULE; c, FRAGMENT OF SKELETON.

gether in a new subgenus (*Stratospongilla*<sup>a</sup>), but differs from them  
in its slender gemmule spicules. On the whole, despite this differ-  
ence, I think that it should be associated with them.

<sup>a</sup> In an account of the fresh-water sponges collected by Prof. Max Weber in  
S. Africa published in the *Zoolog. Jahrbücher*, 1909.



## DESCRIPTIONS OF SEVENTEEN NEW SPECIES OF RECENT CRINOIDS.

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By AUSTIN HOBART CLARK,

*Collaborator, Division of Marine Invertebrates, U. S. National Museum.*

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The authorities of the Indian Museum, Calcutta, have recently done me the honor of intrusting to me for study the very important collections of recent crinoids brought together by the steamer *Investigator* during the course of her work in the Indian Ocean. Many of the new species are represented by a considerable number of specimens, and of these cotypes have been retained and deposited in the U. S. National Museum. The types themselves are in the Indian Museum. The completed report on the collection will be published as one of the series of *Investigator* monographs.

I wish here to record my appreciation of the kindness shown me by the authorities of the Indian Museum through the superintendent, Dr. N. Annandale, and by Dr. F. A. Bather, at whose suggestion the collections were sent to me.

### Family ZYGOMETRIDÆ.

#### Genus EUDIOCRINUS P. H. Carpenter.

##### EUDIOCRINUS ORNATUS, new species.

Centro-dorsal a thin disk, the bare polar area flat, 2.5 mm. in diameter, the cirri arranged in a single marginal row.

Cirri XVIII, 17-18, 10 mm. long; first joint twice as broad as long, second nearly or quite as long as broad, third to fifth twice as long as the proximal diameter, sixth slightly shorter, a more or less marked transition joint; following joints gradually decreasing in length, the terminal joints being only slightly longer than broad; penultimate joint about as long as broad. The third to the sixth joints are very strongly "dice-box shaped," with the distal edge all around produced, except on the dorsal side; from the seventh onward both these features become less marked, and the cirrus becomes somewhat com-

pressed laterally. There are no dorsal spines; opposing spine sharp, prominent, arising from the entire dorsal surface of the penultimate joint, equal to about half the diameter of that joint in height; terminal claw equal in length to the penultimate joint, stout, and strongly curved.

Disk with a few rather large plates along the ambulaera, and well plated in the anal area.

Ends of the basal rays visible as small tubercles in the angles of the calyx; radials projecting slightly beyond the centro-dorsal, gently concave distally;  $IBr_1$  and  $IBr_2$  united by syzygy, forming an oblong syzygial pair from one-third to one-half again as broad as long, the lateral edges straight, barely in apposition basally, the ventro-lateral border slightly produced.

Five arms, 85 mm. long; first brachial oblong, about three times as broad as long; second slightly wedge-shaped, about the same size; third and fourth (syzygial pair) slightly longer on one side than on the other, half again as broad as the median length; next three brachials approximately oblong, twice and one-half as broad as long, the following becoming triangular, as broad as long, and after the proximal fourth of the arm wedge-shaped, as long as broad, and in the terminal portion somewhat longer. The lower brachials have on each side, as far as the lowest pinnule on that side, a slightly produced ventro-lateral edge, corresponding with that on the  $IBr$  series; the brachials have a somewhat concave dorsal surface and very prominent distal ends, everted on the proximal, strongly overlapping on the distal, which gives the animal a curiously ornate appearance. Syzygies occur between the third and fourth brachials, again between the eighth and ninth, and distally at intervals of three, more rarely four, oblique muscular articulations.

$P_c$  5.5 mm. long, moderately stout basally, tapering evenly to the tip, rather strongly prismatic, with twelve joints, the first short, the second not quite so long as broad, the third and fourth squarish, the following gradually increasing in length, being nearly or quite twice as long as broad terminally;  $P_1$  similar to  $P_c$ , with the same number of joints, but somewhat stouter and not tapering so rapidly;  $P_a$  8.5 mm. long, much stouter than  $P_c$ , gradually tapering from the base to the tip with twelve or fifteen joints, the first three about as long as broad, the following very gradually becoming elongated and about twice as long as broad distally; the pinnule is rounded-prismatic;  $P_2$  similar to  $P_a$ ;  $P_b$  6 mm. long, slender, cylindrical, less stout basally than  $P_c$ , gradually tapering and becoming very delicate in the terminal portion, with fifteen or sixteen joints, the first short, the second and third about as long as broad, the following gradually increasing in length and becoming nearly or quite three times as long as broad in the terminal portion;  $P_3$  similar to  $P_b$ ; following pinnules similar,

gradually decreasing in length to 5 mm., then very slowly increasing, reaching a length of 10 mm. distally. The distal ends of the joints of the lower pinnules are more or less produced and spinous.

*Type-specimen*.—Cat. No. 7C, Indian Museum; lat.  $14^{\circ} 04' 30''$  N.; long.  $93^{\circ} 51' 00''$  E.; 41 fathoms.

*Cotype*.—Cat. No. 25478, U.S.N.M., from the same locality.

### Family HIMEROMETRIDÆ.

#### Genus AMPHIMETRA A. H. Clark.

##### AMPHIMETRA MORTENSENI, new species.

Centro-dorsal thick-discoidal, the bare polar area flat, 4 mm. or 5 mm. in diameter; cirrus sockets arranged in two closely crowded alternating marginal rows.

Cirri XVIII–XX, 30–42 (usually about 35), 25 mm. to 30 mm. long; first joint short, about three times as broad as long, second and third about twice as broad as long, the following gradually increasing in length to the ninth or tenth, which is nearly, though never quite, as long as broad; next five to seven joints similar, the following gradually decreasing in length, in almost the whole of the terminal half of the cirrus being about one-half again as broad as long; from the twelfth or fourteenth onward sharp median tubercles or small spines are developed on the dorsal side of each joint, those on the last few joints occupying a position slightly proximal to median; opposing spine much larger than the processes on the preceding joints, triangular, the apex median, arising from very nearly the whole of the dorsal surface of the penultimate joint, equal to about half the diameter of that joint in height; terminal claw longer than the penultimate joint, moderately stout basally, but gradually becoming slender distally, moderately curved.

Radials concealed, or just visible beyond the centro-dorsal;  $IBr_1$  oblong, very short, in close lateral apposition;  $IBr_2$  (axillary) very broadly pentagonal, almost triangular, the lateral edges not quite so long as those of the  $IBr_1$ , about two and one-half times as broad as long;  $IIBr\ 4\ (3+4)$ ;  $IIIBr\ 4\ (3+4)$ ; division series and first two brachials in close lateral apposition and laterally flattened, the dorsal carination only of  $P_D$  being visible exteriorly; synarthrial tubercles usually prominent.

Twenty to twenty-five arms 150 mm. long; first brachial slightly wedge-shaped, short, about three times as broad as its exterior length, almost entirely united interiorly; second about the same size, but more pronouncedly wedge-shaped; third and fourth (syzygial pair) oblong, half again as broad as long; next five or six brachials oblong, nearly or quite four times as broad as long, then slowly becoming wedge-shaped and then almost triangular, four times as broad as long, soon becoming wedge-shaped again, and in the outer half of



the arm oblong and very short, though somewhat longer again terminally. The proximal discoidal brachials are somewhat swollen, and most of the brachials have slightly overlapping distal ends. Syzygies occur between the third and fourth brachials, again between the thirteenth and fourteenth to thirty-first and thirty-second (usually somewhere between the sixteenth and twenty-fifth, with sometimes an extra one from two to four or five brachials beyond the first), and distally at intervals of two to thirteen (usually eight to twelve) oblique muscular articulations.

$P_D$  7 mm. long, moderately stout basally, but tapering rapidly and becoming slender in its distal half, with about twenty-five joints, at first three times as broad as long, becoming twice as broad as long at the sixth, and squarish in the terminal portion; some of the lower joints are bluntly carinate;  $P_1$  10 mm. long, with 30 joints, slightly less stout basally than  $P_D$  and tapering somewhat less rapidly; joints at first about twice as broad as long, becoming as long as broad at about the eighth, and somewhat longer than broad terminally;  $P_2$  15 mm. long, stouter than  $P_1$ , tapering evenly to a delicate tip, with 30 joints, at first about half again as broad as long, becoming squarish at the eighth or ninth, and about twice as long as broad at the tip;  $P_3$  22 mm. long, stouter than the preceding, with 30 joints, at first broader than long, becoming squarish about the tenth, and longer than broad terminally; the pinnule is more or less carinate in its proximal half and has a moderate supplementary ridge on the distal half of the outer side;  $P_4$  resembling  $P_3$ , but very slightly longer and slightly stouter and more carinate;  $P_5$  like  $P_3$ ;  $P_6$  10 mm. long, resembling  $P_1$ , but somewhat more strongly carinate proximally; following pinnules gradually decreasing to 7 mm. in length and losing the basal carination, then increasing to 12 mm. distally. On some arms  $P_5$  is small as described for  $P_6$ , and again  $P_4$  may also be small, while occasionally  $P_2$  and  $P_4$  are similar and  $P_3$  is greatly enlarged; sometimes  $PP_{2, 3}$  and  $4$  are as described for  $PP_{3, 4}$  and  $5$ . On one or more of the inner arms of each ray  $P_3$  is often much larger than on the outer, while the adjacent pinnules are reduced.

*Type-specimen*.—Cat. No. 42B., Indian Museum; Port Blair, Andaman Islands.

*Cotype*.—Cat. No. 25479, U.S.N.M.; from the same locality.

I have dedicated this species to Dr. Th. Mortensen, of Copenhagen, in recognition of his valuable contributions to the knowledge of the Echinoderms.

#### Genus HETEROMETRA A. H. Clark.

##### HETEROMETRA COMPTA, new species.

Centro-dorsal discoidal, the bare polar area flat, slightly convex or slightly concave, about 5 mm. in diameter; cirrus sockets arranged in a single more or less irregular marginal row.



Cirri XVIII-XXIII, 31-35, 23 mm. to 25 mm. long; first joint very short, the next three nearly two and one-half times as broad as long, the following gradually increasing in length to the sixth or seventh, which is about as long as broad; next five to seven joints usually slightly longer than broad (sometimes squarish), the following gradually decreasing in length, the terminal fifteen or rather more being half again to twice as broad as long; at about the fifteenth joint dorsal tubercles are developed, at first involving only the distal portion of the dorsal surface, later arising in a slightly convex line from near the proximal end, the apex being subterminal; these tubercles are narrow, laterally occupying only a small portion of the median part of each joint, and are slightly rounded dorsally; on the last three joints the tubercles become somewhat sharper, more erect, and move to a median position; opposing spine small (though larger than the tubercle on the preceding joint), blunt, arising from the entire dorsal surface of the joint, the apex median or submedian in position, in height equal to about one-third the diameter of the penultimate joint; terminal claw somewhat longer than the penultimate joint, rather stout and strongly curved.

Ends of the basal rays and radials concealed; IBr<sub>1</sub> very short and band-like; IBr<sub>2</sub> (axillary) short, almost triangular, two and one-half times as broad as long; IIBr 4(3+4), in apposition laterally, though not laterally flattened; IIBr<sub>1</sub> entirely united interiorly; IIIBr 2, rarely 4(3+4); IVBr 2, but rarely present.

Sixteen to twenty-five arms 110 mm. long; first two brachials wedge-shaped, three times as broad as long exteriorly, the first interiorly united; following four or five brachials oblong, about four times as broad as long, then gradually becoming wedge-shaped, almost triangular, about three times as broad as long, and less oblique and somewhat longer on the outer portion of the arms. The dorsal surface of the arms is perfectly smooth. Syzygies occur between the third and fourth brachials, again between the thirteenth and fourteenth to twentieth and twenty-first (usually in the vicinity of the fifteenth) and distally at intervals of seven to eleven (most commonly eight or nine) oblique muscular articulations.

P<sub>D</sub> 7.5 mm. long, moderately stout basally, but tapering rather rapidly in the proximal half and slender distally, with twenty-five joints, at first twice as broad as long, becoming squarish after the tenth; the first four joints are strongly carinate, this carination decreasing from this point onward and disappearing after the middle of the pinnule; P<sub>1</sub> 13 mm. long, slightly stouter than P<sub>D</sub> basally, tapering gradually, and becoming slender in its distal third, with twenty-six joints, at first twice as broad as long, becoming squarish after the ninth and somewhat longer than broad in the terminal portion; the first seven or eight joints are rather strongly carinate and in

addition have a low sharp ridge running along their exterior surface at the base of the carinate processes;  $P_2$  similar to  $P_1$  and of the same length, but the low ridge just described may be traced to about the twelfth joint;  $P_3$  9 mm. long with nineteen joints, similar to the two preceding pinnules, but slightly less stout;  $P_4$  small, 6 mm. long, tapering rapidly in the proximal half and becoming very slender distally, with sixteen joints, at first twice as broad as long, becoming squarish about the ninth, and longer than broad distally, the first six joints carinate like those of the preceding pinnules;  $P_5$  similar, 5.5 mm. or 5 mm. long;  $P_6$  and the following pinnules 6 mm. long with seventeen joints, at first twice as broad as long, becoming squarish about the eighth and twice as long as broad terminally; the pinnules are about as stout basally as the two preceding, tapering rapidly in the proximal half and becoming very slender distally; the carination of the proximal joints is slightly marked on the first four; this carination later becomes restricted to the second and third joint only, and disappears entirely in the outer half of the arm.

*Type-specimen*.—Cat. No. 4 F. =  $8 \frac{9}{14}$ , Indian Museum; Pedro Shoal, north of the Laccadive Islands.

*Cotype*.—Cat. No. 25480, U.S.N.M.; from the same locality.

**HETEROMETRA SINGULARIS, new species.**

Centro-dorsal discoidal, the bare polar area flat, 1.5 mm. in diameter; cirrus sockets arranged in a single crowded, more or less irregular marginal row.

Cirri XVII, 21–25, 12 mm. long; first joint short, second about twice as broad as long, third somewhat longer, fourth about as long as broad, next two slightly longer than broad, the following gradually decreasing in length, the terminal fifteen being one-third or one-half again as broad as long; at the seventh subterminal dorsal spines begin to develop which soon become long and prominent; opposing spine large and long, much larger than the spines on the preceding joints, triangular, the apex terminal, arising from the whole surface of the penultimate joint and about equal to the diameter of that joint in length; terminal claw nearly twice as long as the penultimate joint, slender, abruptly curved proximally, becoming nearly straight distally.

Disk with a few calcareous granules in the anal area, especially on the anal tube.

Radials short, oblong, the dorsal surface with numerous prominent rounded tubercles;  $IBr_1$  short, oblong, slightly over four times as broad as long, in close lateral apposition;  $IBr_2$  (axillary) broadly pentagonal, almost triangular, twice as broad as long, the lateral edges shorter than those of the  $IBr_1$ ;  $IIBr$  4(3+4); joints up to and including the second brachial exteriorly and the fourth interiorly,

as well as the first two joints of the first three pinnules, in close apposition and sharply flattened, the lateral edges somewhat produced.

Eleven arms (in the type), 40 mm. long; first two brachials subequal, wedge-shaped, about twice as broad as the exterior length, the first interiorly united; third and fourth (syzygial pair) slightly longer interiorly than exteriorly, nearly three times as broad as the interior length; next four brachials oblong, nearly four times as broad as long, then becoming almost triangular, about three times as broad as long, then gradually lengthening (though remaining almost triangular) to about twice as broad as long, and at a point somewhat beyond the end of the proximal third rather quickly becoming wedge-shaped, almost oblong, about two and one-half times as broad as long. From about the ninth onward the brachials have prominent distal ends, though they do not overlap the bases of the succeeding joints. Syzygies occur between the third and fourth, ninth and tenth, and fifteenth and sixteenth brachials (the second sometimes omitted), and distally at intervals of seven to ten oblique muscular articulations.

$P_D$  4.5 mm. long, moderately stout basally, but tapering rapidly in the proximal half, and slender distally, with 20 joints, at first about twice as broad as long, becoming squarish after the eighth; the second to the seventh joints are rather strongly carinate;  $P_1$  similar, very slightly longer and stouter;  $P_2$  6 mm. long, considerably stouter and stiffer than the preceding, and rather more strongly carinate basally, with about 20 joints, the first 7 (except for the carinate processes) squarish, the remainder slightly longer than broad, becoming about half again as long as broad distally; the ridge in the distal half of the outer side is but little marked;  $P_3$  3 mm. long, much smaller than any of the preceding, with about 12 joints, at first broad, becoming squarish about the fifth, and nearly twice as long as broad distally; the second-fifth joints are carinate; following pinnules similar and about the same length, the joints becoming gradually longer and the basal carination gradually less; distal pinnules, 5 mm. long. On the arms arising from a IBr axillary,  $P_1$ ,  $P_2$ , and  $P_3$  are usually as described for  $P_D$ ,  $P_1$ , and  $P_2$ , and  $P_4$  is much smaller, as described for  $P_3$ ; but occasionally  $P_2$  is enlarged and similar to  $P_3$ , as described, instead of being small like  $P_1$ .

*Type-specimen*.—Cat. No. 7A, Indian Museum; southern portion of Malacca Strait.

### Genus STEPHANOMETRA A. H. Clark.

#### STEPHANOMETRA CORONATA, new species.

This species is most closely related to *S. tenuipinna*.

Cirri XXII–XXIII, 25–30, 22 mm. long, resembling those of *S. tenuipinna*; the longest joints are about one-third longer than broad; the ninth, tenth, or eleventh is a well-marked transition joint.



Radials projecting slightly beyond the edge of the centro-dorsal;  $IBr_1$  oblong, short, about three and one-half or four times as broad as long, not in lateral apposition, with a rounded ventro-lateral process in the proximal half;  $IBr_2$  (axillary) broadly pentagonal, twice as broad as long, the lateral edges about half as long as those of the  $IBr_1$ , produced into a rounded prominent ventro-lateral process; synarthrial tubercles rather prominent;  $IIBr$ ,  $IIIBr$ , and  $IVBr$  (when present) 2; elements of division series and first brachials with prominent rounded ventro-lateral processes.

Thirty-three or thirty-four arms 120 mm. long, in general resembling those of *S. tenuipinna*.

$P_1$  14 mm. long, stout, stiff, and spine-like, with fourteen joints, the first two somewhat broader than long, the third to the fifth squarish, the remainder becoming gradually elongated and twice as long as broad distally;  $P_2$  and  $P_3$  exactly like  $P_1$ ;  $P_4$  10 mm. long with ten joints, resembling the preceding;  $P_5$  7 mm. long, spine-like as the preceding, but somewhat more slender, with eight joints; following pinnules decreasing gradually in length,  $P_8$  being 5 mm. long with eight joints; subsequent pinnules remaining of similar length, but decreasing in stiffness and increasing in the number of joints,  $P_{13}$  being 5 mm. long with twelve joints, the third squarish, the distal twice as long as broad, only slightly stiffened proximally; distal pinnules slender, 9 mm. long.

*Type-specimen*.—Cat. No. 18 II= $\frac{451}{A.S.IE.}$ , Indian Museum; "India."

*Cotype*.—Cat. No. 25481, U.S.N.M.; from "India."

### Family COLOBOMETRIDÆ.

#### Genus COLOBOMETRA A. H. Clark.

##### COLOBOMETRA DISCOLOR, new species.

Cirri XVIII–XXII, 29–40 (usually about 35), 25 mm. to 30 mm. long, slender, resembling those of *C. perspinosa*, but with the distal ends of the joints not so strongly spinous.

Radials projecting slightly beyond the centro-dorsal;  $IBr_1$  oblong, slightly over twice as broad as long, the ventro-lateral borders slightly produced into a thin border, by which they are in apposition;  $IBr_2$  (axillary) broadly pentagonal, twice as broad as long, the lateral edges somewhat more than half the length of those of the  $IBr_1$ , making with them a straight line, and with the same ventro-lateral projection; a slight constriction is usually present just below the lateral angles.

Ten arms, 80 mm. long, rather slender, resembling in general those of *C. suavis*.

$P_a$  absent;  $P_1$  6.5 mm. long, small, tapering rapidly to a slender and delicate tip, with 15 or 16 joints; first joint twice as broad as



long, second somewhat longer, third about as long as broad, the fourth similar, the following very gradually increasing in length to about half again as long as broad, and becoming squarish again in the terminal 4 or 5;  $P_2$  15 mm. long, moderately stout and very stiff and spine-like, with about 20 joints, the first about twice as broad as long, the second slightly longer, the third nearly half again as long as broad, the remainder about twice as long as broad; beginning on the second joint there is a faintly indicated, broadly rounded keel running along the middle of the outer side, as on  $P_1$ ; on the third and following joints the distal dorsal edge projects in the line of this keel in a narrow fringe of spines, which broadens on succeeding joints, the spines at the same time becoming longer, and is supplemented by additional spines on the ventro-lateral angles of the joints;  $P_3$  similar to  $P_2$ , usually about 1 mm. shorter;  $P_4$  10 mm. long, resembling  $P_2$  and  $P_3$ , though not quite so stiff, with 15 joints;  $P_5$  and following pinnules very slowly decreasing in length and stiffness, at the same time becoming more slender, with the spines on the distal ends of the joints less and less pronounced;  $P_6$  is 8 mm. long and  $P_{10}$  is 7 mm. long, each with 15 joints; from this point the pinnules very gradually increase to 10 mm. in length distally, the distal pinnules being slender, comparatively little stiffened, with 20 to 22 joints, which have moderately everted ends armed with fine spines; the distal pinnules are somewhat compressed laterally.

*Type-specimen*.—Cat. No. 9C., Indian Museum; lat.  $14^{\circ} 04' 30''$  N.; long.  $93^{\circ} 51' 00''$  E.; 41 fathoms.

*Cotype*.—Cat. No. 25482, U.S.N.M.; from the same locality.

### Genus CYLLOMETRA A. H. Clark.

#### CYLLOMETRA TAPROBANES, new species.

Centro-dorsal thin, discoidal, the bare polar area flat, 2 mm. to 3 mm. in diameter; cirrus sockets arranged in a single, slightly irregular, crowded marginal row.

Cirri XX–XXI, 25–29, 12 mm. or 13 mm. long; first joint short, the next about two and one-half times as broad as long, the following slowly increasing in length to the fifth or sixth, which is twice as broad as long, and the tenth or twelfth, which is half again as broad as long, and still further increasing, so that the antepenultimate and one or two of the preceding joints are about as long as broad; fifth to seventh and succeeding joints with the distal dorsal edge prominent, forming a low transverse ridge which slowly moves anteriorly, attaining a median position on about the twelfth, and gradually narrows distally, becoming reduced to a small median tubercle on the last twelve; opposing spine prominent, rather slender, median, equal in height to about one-half the diameter of the penultimate

joint; terminal claw slightly longer than the penultimate joint, moderately slender, and moderately curved, rather more proximally than distally.

Radials projecting very slightly beyond the centro-dorsal, slightly separated distally;  $IBr_1$  oblong or slightly trapezoidal, four times as broad as long;  $IBr_2$  (axillary) broadly pentagonal, twice as broad as long; synarthrial tubercles moderately developed.

Arms 10, about 80 mm. long, resembling those of *C. studeri*; distal ends of the brachials very slightly, if at all, produced.

$P_a$  absent;  $P_1$  4.5 mm. long, small and slender, with about 14 joints, the first short, the second slightly longer, the third squarish, those in the distal portion being half again as long as broad;  $P_2$  8 mm. long, stouter and stiffer than  $P_1$ , though not especially enlarged, with 15 to 17 joints, the first short, the second and third squarish, the remainder one-third to one-half again as long as broad, becoming again somewhat shorter at the extreme tip; the joints in the distal half have slightly enlarged distal ends;  $P_3$  6 mm. long, less stout than  $P_2$ , but similar to it, with 14 joints;  $P_4$  5 mm. long, slightly less stout than  $P_3$ , but similar, with 12 joints;  $P_5$  and following pinnules 4 mm. long, about as stout as  $P_4$ , but not stiffened, with 12 joints, the third squarish, the remainder longer than broad, becoming half again as long as broad in the distal half; the distal ends of the component joints are slightly everted and spinous; distal pinnules slender, 7 mm. long, the joints smooth.

*Type-specimen*.—Cat. No.  $\frac{5542}{7}$ , Indian Museum; off Colombo Light House, Ceylon;  $26\frac{1}{2}$  fathoms.

*Cotype*.—Cat. No. 25483, U.S.N.M.; from the same locality.

### Family THALASSOMETRIDÆ.

#### Subfamily THALASSOMETRINÆ.

#### Genus CROTALOMETRA A. H. Clark.

##### CROTALOMETRA ANNANDALEI, new species.

Centro-dorsal columnar, the tip truncated conical as in *Asterometra*, 5 mm. long by about 5 mm. broad at the base; cirrus sockets arranged in ten columns of usually three each, the columns of adjacent radial areas being closely crowded and more or less alternating, the two columns of each radial area being separated by a slightly concave median area of about half their width; polar area with five more or less marked interradi al ridges which terminate in five small tubercles about the apex.

Cirri comparatively slender, XXX, 62–79, 65 mm. long; first three joints approximately equal, short, about twice as broad as long, the following gradually increasing in length, becoming squarish on the fifth or sixth and half again or nearly twice as broad as long on the

eighth or ninth; next three or four joints similar, the length then very slowly decreasing, the joints in the middle of the cirrus being squarish and those in the distal part about twice as broad as long; eighth, ninth, or tenth a transition joint; shortly after the transition joint the median part of the distal dorsal edge begins to become prominent; this very slowly increases in height, arising from progressively more and more of the dorsal surface of the joints, which become progressively more and more carinate, so that in the terminal forty-five or fifty the dorsal surface is produced into a sharp, thin keel, straight in front, convex posteriorly, the outer edge parallel with the median line of the cirrus, in height equal to about one-third the diameter of the joints which bear them; opposing spine small and blunt, arising from the entire surface of the penultimate joint, the apex subterminal or central, in height equal to about one-third the diameter of the penultimate joint; terminal claw small, about equal in length to the penultimate joint, stout, and moderately curved. The cirri are rounded in the basal third, then becoming strongly compressed laterally and, when viewed from the side, somewhat broader.

Ends of the basal rays visible as dorso-ventrally elongated tubercles in the angles of the calyx; a deep and narrow cleft between the radials and the centro-dorsal; radials very narrow, convex proximally, concave distally, with a small, sharp tubercle in the median part of the proximal border;  $IBr_1$  about three times as broad as long, the proximal border convex, the distal concave, in close lateral apposition, and extending rather well up into the angles of the calyx; the lateral edges are more or less denticulate, and there is a low, though sharp, serrate median keel;  $IBr_2$  (axillary) slightly longer than broad, shield-shaped, the posterior border produced into a rounded projection incising the  $IBr_1$ , the anterior edges concave, the anterior angle somewhat produced, the lateral edges rather strongly denticulate; it bears a sharp serrate median keel in the proximal two-thirds;  $IIBr\ 4\ (3+4)$ , strongly convex dorsally, in close apposition and sharply flattened like the  $IBr$  series, the lateral edges somewhat produced and strongly denticulate;  $IIBr_{3+4}$  centrally constricted with the lateral angles produced as in the other species.

Twenty arms, 115 mm. long; first brachial short, slightly longer exteriorly than interiorly, interiorly united, somewhat incised by the second, which is nearly twice as large and has a rounded posterior projection; these two brachials, like the  $IBr_1$  and  $_2$ , have a slightly marked median carination; third and fourth brachials (syzygial pair) not quite so long as broad, somewhat constricted centrally; next five or six brachials almost oblong, about twice as broad as long, the surface rather strongly concave, then becoming wedge-shaped and soon triangular, nearly as long as broad, and after the middle of the arm wedge-shaped again and about as long as broad. The arms are



at first evenly rounded dorsally, but after the basal third they gradually become compressed and more sharply rounded dorsally, and in the outer half very narrow and very sharply rounded dorsally, though not really carinate; after the basal third of the arm the brachials develop slightly projecting and finely spinous distal edges. The dorsal (but not the dorso-lateral) side of the fourth and following brachials is covered with fine short spines, which gradually become coarser after the proximal third of the arm and tend to arrange themselves into longitudinal lines; joints of the division series and arm bases with strongly denticulate borders. Syzygies occur between the third and fourth brachials, again between the twenty-fifth and twenty-sixth to thirty-fifth and thirty-sixth (usually in the vicinity of the twenty-ninth) and distally at intervals of five to seventeen (usually seven to ten) oblique muscular articulations.

$P_D$  12 mm. long, moderately stout in the proximal half, but becoming slender distally, with about twenty joints, all of which are approximately as long as broad, and the basal two-thirds of which are strongly carinate;  $P_1$  10 mm. long, similar to  $P_D$ , but less stout basally;  $P_2$  6 mm. long, much more slender than  $P_1$ , tapering evenly from the base to the tip, with fifteen joints, the proximal four or five squarish, then longer than broad, and about twice as long as broad terminally.  $P_3$  similar, 6 mm. long;  $P_4$  and following pinnules 5 mm. long with about thirteen joints, less slender distally than the preceding; the joints have slight overlapping spines developed on the distal edge along the dorsal crest; distal pinnules 10 mm. long, rather slender, with about twenty joints, the first short and crescentic, the second trapezoidal, about as broad distally as its median length, the following half again as long as broad, the terminal four or five disproportionately small; the dorsal crest is sharp and somewhat spinous.

*Type-specimen*.—Cat. No. 20A.— $S_{46}^{493}$ , Indian Museum; Malay Archipelago; 30 fathoms.

*Uotype*.—No. 25484, U.S.N.M.; from the same locality.

This species is named for Dr. N. Annandale, the superintendent of the Indian Museum, through whose courtesy the exceptionally interesting collections of that institution have been sent to me for study.

#### Subfamily CHARITOMETRINÆ.

#### Genus CRINOMETRA A. H. Clark.

#### CRINOMETRA PULCHRA, new species.

Cirri XX–XXIV, 18–20, moderately slender, 30 mm. to 40 mm. long.

Ends of the basal rays visible as rather large tubercles in the angles of the calyx; radials concealed, or at most forming a  $\wedge$ -shaped ridge over the ends of the basal rays;  $IBr_1$  very nar-



row, chevron-shaped or crescentic, or entirely concealed;  $I\text{Br}_2$  (axillary) large, rhombic, half again to twice as long as broad, the edges all around smooth and prominent, with a moderate rounded median carination;  $I\text{Br}_2$ , the first very short, the axillary rhombic, about twice as broad as long;  $II\text{Br}_2$ , similar to the  $I\text{Br}_2$ , developed interiorly in 1,2,2,1 order. The division series are perfectly smooth dorsally, in close lateral apposition and sharply flattened; the edges of the component joints are slightly prominent, and the axillaries have a slight broadly rounded median ridge, most pronounced on the first. One specimen has one  $I\text{Br}$  series, and one  $II\text{Br}$  series 4 (3+4).

Thirty arms, 150 mm. long, resembling, except in ornamentation, those of the other species of the genus; after the third or fourth brachial strongly overlapping distal ends are developed, the middle of which is swollen into a broad tubercle which may extend backward to the proximal end of the joint; after the thirtieth brachial this gradually disappears.

The pinnules are essentially as in the other species of the genus.

*Type-specimen*.—Cat. No. 25473, U.S.N.M.: from *Albatross* Stations Nos. 2319–2350, off Havana, Cuba; depth between 33 and 279 fathoms.

**CRINOMETRA MARGARITACEA, new species.**

Cirri XX, 13–15, 20 mm. long.

Ends of the basal rays visible in the angles of the calyx, bearing one or more long tubercles; radials concealed;  $I\text{Br}_1$  very short, five or six times as broad as long, the edges parallel and slightly curved;  $I\text{Br}_2$  (axillary) rhombic, about two and one-half times as broad as long;  $I\text{Br}_2$ ;  $II\text{Br}_2$ ;  $II\text{Br}_2$ , developed interiorly, but never present in the full series. The division series and first two brachials are slightly convex dorsally and are in close lateral apposition and sharply flattened laterally; the first eighteen or twenty brachials are also sharply flattened laterally. The axillaries and preceding joints are separated in the outer part of their contiguous surfaces, forming rhombic water pores; the first and second brachials are similarly separated interiorly. The ornamentation consists of moderately large blunt tubercles distributed evenly over the surface of the division series, becoming gradually less marked after the second brachial and disappearing altogether at about the end of the proximal fourth of the arm. The  $I\text{Br}$  and  $II\text{Br}$  series and the first two brachials have a low but prominent rounded narrow median carination; this is continued onto the arm bases in the shape of prominent median tubercles on each joint which disappear at about the end of the proximal fourth of the arm.

Twenty-one to twenty-nine arms, resembling in structure those of other species of the genus.

The pinnules are of the type common to most of the species of the genus, but are somewhat more slender, the genital pinnules not being so much expanded.

*Type-specimen*.—Cat. No. 25472, U.S.N.M.; from *Albatross* Station No. 2154, off Havana, Cuba; 310 fathoms.

CRINOMETRA CONCINNA, new species.

Cirri XX, 14–18 (usually 15 or 16) 25 mm. to 30 mm. long.

Ends of the basal rays visible in the angles of the calyx, bearing one or more long tubercles; radials concealed;  $IBr_1$  very short often more or less concealed by the centro-dorsal, curved and band-like or narrowly crescentic;  $IBr_2$  (axillary) rhombic to approximately triangular, two and one-half times as broad as long, the lateral edges as long as those of the  $IBr_1$ , and often, like them, reduced to a point;  $IIBr\ 2$  (once 4 ( $3 + 4$ ) and twice 4 united in two synarthrial pairs in eight specimens);  $IIBr\ 2$ , developed interiorly; edges of the joints to the third brachial everted and raised, usually broken up into high blunt tubercles which intermingle more or less with similar high blunt, more or less confluent tubercles on the dorsal surface of the joints; division series (except the  $IBr$ ) and first two brachials usually with a high, rather narrow, median ridge, higher than the tubercles on the dorsal surface of the joint; this is sometimes partially or entirely broken up into two or three dorso-ventrally elongate tubercles, larger than any of the others on the joints. The proximal edge of the axillaries and the inner proximal edge of the second brachial are curved upward, while the distal lateral angles of the joints preceding the axillaries, and the inner distal angle of the first brachials, are cut away, leaving prominent openings, which serve as water pores. The division series are only very slightly convex dorsally, and are in very close lateral apposition; the first sixteen brachials are flattened laterally.

Thirty arms 150 mm. long, resembling those of other species of the genus; the lower brachials to about the fifteenth have strongly everted distal ends, which are usually more or less crenulate, or may be tubercular; there is usually a prominent central tubercle, dorso-ventrally elongate, and also some more or less obsolete tubercles on the dorsal surface; from the fifteenth onward the brachials are almost perfectly smooth dorsally.

*Type-specimen*.—Cat. No. 25476, U.S.N.M.; from *Albatross* station No. 2342, off Havana, Cuba; 201 fathoms.

CRINOMETRA INSCULPTA, new species.

Cirri XX, 15–18, 25 mm. to 30 mm. long.

Ends of the basal rays visible in the interradian angles as a cluster of high tubercles, with difficulty separable from the similarly modified

surface of the surrounding skeletal elements; radials concealed;  $IBr_1$  usually concealed except in the angles of the calyx; very short;  $IBr_2$  (axillary) triangular, three or four times as broad as long;  $IIBr$  4 (3+4) and 2, usually both in the same specimen, but the former always in the majority;  $IIIBr$  2 (1 + 2), or 2 after a  $IIBr$  2 series (rarely, when developed exteriorly, 4 (3 + 4) or 4 (1 + 2; 3 + 4)), developed interiorly in 1, 2, 2, 1 order, but never present in the full series. The elements of the division series are in close apposition, no water-pores being present. The division series and lower brachials are but slightly convex dorsally, and are in close lateral apposition and sharply flattened. The elements of the  $IBr$  series are thickly and evenly covered with prominent tubercles resembling those on the dorsal pole of the centro-dorsal. These sometimes arrange themselves in a more or less linear series in the median line, or there may be a more or less distinct median keel, which, however, is never very well marked. This evenly tubercular ornamentation may encroach somewhat upon the lower elements of the  $IIBr$  series, and always extends a considerable distance up into the angles of the calyx and between the  $IIBr$  series, narrowing to a point anteriorly, as does the somewhat similar ornamentation in *Mariametra subcarinata*. The elements of the  $IIBr$  and  $IIIBr$  series and the lower brachials have more or less (usually strongly) crenulate or tubercular edges, and the dorsal surface usually bears a few small scattered tubercles; along the median line they bear large and prominent, dorso-ventrally elongate, narrow, dorsally rounded tubercles, which form a conspicuous narrow carination. The lower brachials have very strongly tubercular or dentate distal ends, in the center of which is a single large tubercle, these large tubercles forming a median line of prominent tubercles, which continues the carination of the division series out onto the arms, gradually dying away and disappearing at about the end of the proximal fourth. The prominent eversion of the distal edges of the brachials becomes distally less and less strongly dentate, at the same time becoming less and less erect, until at about the twentieth brachial it becomes merely a moderately marked, finely spinous overlap, and so continues to the ends of the arms. The brachials to about the twentieth are sharply flattened laterally.

The pinnules are as in other species of the genus.

*Type-specimen*.—Cat. No. 25477, U.S.N.M.: from *Albatross* station No. 2753, off the windward coast of St. Vincent; 281 fathoms.

CRINOMETRA GEMMATA, new species.

Cirri XX, 12–15, 20 mm. to 25 mm. long.

Ends of the basal rays visible as elongate tubercles in the angles of the calyx, usually covered with short, fine spines; radials concealed, or just visible over the ends of the basal rays;  $IBr_1$  very



short and band-like, of uniform height, strongly curved, the proximal edge everted and dentate, and with a row of small pointed tubercles, sometimes more or less confluent, midway between the anterior and posterior borders;  $IBr_2$  (axillary) rhombic, twice and one-half as broad as long, the anterior and posterior angles approximately equal, the lateral edges about equal to those of the  $IBr_1$ ;  $IIBr$  4 (3+4) (in one specimen twice 2);  $IIIBr$  2 (1+2), but only present in a single instance, developed interiorly. The division series are in close lateral apposition and are sharply flattened laterally; they are strongly convex dorsally, so that the dorsal portion of  $P_D$  is exposed. The division series and arms to the fourteenth or eighteenth brachial are thickly covered with numerous uniform, small, sharp, conical tubercles, which exhibit a tendency to arrange themselves in horizontal rows; these are more numerous and more slender along the edges of the division series. Seen without a glass, the proximal portion of the animal has the appearance of being finely and evenly granulated.

Nineteen to twenty-one arms, 100 mm. to 125 mm. long, resembling, except for the basal ornamentation as described, those of other species of the genus.

The pinnules are essentially as in the other species.

*Type-specimen*.—Cat. No. 25474, U.S.N.M.; from *Albatross* station No. 2330; off Havana, Cuba; 121 fathoms.

### Family ANTEDONIDÆ.

#### Genus PSATHYROMETRA A. H. Clark.

##### PSATHYROMETRA MIRA, new species.

Centro-dorsal conical, rounded at the apex, 4 mm. broad at the base and 4 mm. high, divided into five radial areas by five shallow interradi al furrows, each equal in width to nearly or quite the diameter of the adjacent cirrus sockets; cirrus sockets closely crowded, regularly arranged in two converging columns in each radial area, with a single socket, the remnant of a third column, between the distal ends of the first sockets of the outer columns, which come together just beneath it.

Cirri XL, lacking in both specimens.

Ends of the basal rays visible as small tubercles in the angles of the calyx, but with difficulty separable from the general surface of the centro-dorsal and radials; radials even with the edge of the centro-dorsal in the median line, but extending up in the angles of the calyx and entirely separating the bases of the  $IBr_1$ ;  $IBr_1$  oblong, slightly over twice as broad as long, evenly rounded dorsally and laterally;  $IBr_2$  (axillary) broadly pentagonal, about as long as broad, the lateral edges not quite so long as those of  $IBr_1$ , convex, the lateral angles somewhat produced outward.



Ten arms, all broken off at the base in the two specimens at hand; first brachial slightly wedge-shaped, about twice as broad as its exterior length, entirely free interiorly; second brachial considerably larger, approximately oblong, not quite so long as broad; third and fourth brachials (syzygial pair) not quite so long as broad; the remainder of the arms and the pinnules, so far as can be judged from the fragments, are similar to those in other species of the genus. The synarthrial tubercles are very slightly marked.

*Type-specimen*.—Cat. No. 9G=<sup>10.12</sup><sub>9</sub>, Indian Museum; lat. 11° 31' 40'' N., long. 92° 46' 40'' E.; 188–220 fathoms.

*Cotype*.—Cat. No. 25485, U.S.N.M.; from the same locality.

#### Genus MASTIGOMETRA A. H. Clark.

##### MASTIGOMETRA MICROPODA, new species.

Centro-dorsal low hemispherical, 4 mm. in diameter at the base, the polar area slightly convex or flattened; cirrus sockets closely crowded, very numerous, in four or five alternating rows.

Cirri L-XC, 16, about 10 mm. long; first two joints short, rather over twice as broad as long, third as long as broad to about one-third longer than broad, fourth and fifth slightly longer; succeeding joints subequal, about as long as broad; third to sixth joints slightly "dice-box shaped," the remainder with the ventral surface practically straight and the dorsal with a slight median concavity (in lateral view); no trace of dorsal spines or overlap; cirri becoming somewhat compressed in the distal two-thirds, and therefore appearing very slightly broader in lateral view; opposing spine represented by a slight tubercle, terminally situated, which may be obsolete.

Scattered calcareous granules are present along the disk ambulacra, and single interradial plates may be present between the IBr<sub>1</sub>.

Radials even with the edge of the centro-dorsal; IBr<sub>1</sub> very short, five or six times as broad as long, of uniform height, not quite in apposition basally, the lateral edges diverging distally; IBr<sub>2</sub> (axillary) triangular, about half again as broad as long, the anterior angle somewhat produced, the proximal border as long as the proximal edge of the IBr<sub>1</sub>.

Ten arms, probably about 80 mm. long, their structure being the same as in *M. flagellifera*. The distal intersyzygial interval is three oblique muscular articulations.

P<sub>1</sub> 15 mm. long, much stouter basally than the succeeding, though tapering to an exceedingly slender and delicate flagellate tip; P<sub>2</sub> 9 mm. long; following pinnules gradually decreasing in length. The pinnules are of the same proportions and structure as are those of *M. flagellifera*.

*Type-specimen*.—Cat. No. 14 H., Indian Museum; " ?India."

*Cotype*.—Cat. No. 25486, U.S.N.M.; " ?India."

The only specimen in the collection with a definite locality is a small and much broken one, which was dredged off Colombo Light, Ceylon, in  $26\frac{1}{2}$  fathoms.

Family PENTACRINITIDÆ.

Genus HYPALOCRINUS A. H. Clark.

HYPALOCRINUS SPRINGERI, new species.

Stem slender, 4 mm. in diameter, rounded-pentagonal in cross section, the sides smooth, flat, or very slightly convex; interarticular pores extending to the eighth node; internodals, 10 (rarely 9 or 11) of equal size, each face slightly over twice as broad as high; nodals slightly longer than the internodals, the small transversely oval cirrus sockets touching the distal (lower) border and extending upward to the proximal fourth of the joint face; neither the supra- nor infranodals are modified in any way.

Cirri slender and delicate, twelve times the diameter of the stem (48 mm.) in length, with 50 joints; first joint very short, the following gradually increasing in length to the fourth, which is twice as broad as long, and further increasing to the sixth, which is about as long as broad; following joints slightly longer than broad, but in the terminal fourth becoming again about as long as broad; from the twentieth or twenty-third joint onward small but prominent median dorsal tubercles are developed; terminal claw small and blunt, conical, twice as long as broad at the base, slightly longer than the preceding joint.

Infrabasals present, resembling those of *Isocrinus decorus*; basals prominent externally, rhombic in outline, just contiguous by their lateral angles, strongly convex exteriorly, bearing from one to three prominent tubercles; in dorsal view the basals form a figure similar to that made by the basals of *Isocrinus decorus*; radials large, strongly convex proximally, slightly concave distally, about half again as broad as long, ornamented with a few coarse, high, tubercles, irregularly placed;  $IBr_1$  oblong, about twice as broad as long, without ornamentation; the lateral edges are just in apposition, but are not flattened; they are cut away somewhat anteriorly and posteriorly, forming small rhombic pores on the lines of articulation between the  $IBr_1$  and the radials, and the  $IBr_1$  and  $_2$ ;  $IBr_2$  (axillary) short and broad, triangular, twice and one-half as broad as long, the anterior edges everted and produced into a high scalloped ridge;  $IBr_1$  and  $_2$  united by syzygy;  $IIB\ 2$ , the distal edges of the joints standing out in high prominent scalloped ridges;  $IIIBr\ 4$  (3+4), the distal edges of the  $IIIBr_1$ ,  $_2$ , and  $_4$  forming high scalloped vertical ridges.

About twenty-five arms 140 mm. long, the terminal 30 mm. being slender and with only very rudimentary pinnules, as in *Metacrinus*

and in *H. naresianus*; first brachial very obliquely wedge-shaped, the distal edges forming a straight line with those of adjacent first brachials, and standing out in a high scalloped vertical ridge or bearing two or three high tubercles, the interior edges entirely united; second brachial smaller, wedge-shaped, about twice as long outwardly as inwardly, the distal edge everted as in the preceding; following brachials obliquely wedge-shaped, about twice as broad as long, after about the twelfth becoming oblong, at first half again as broad as long, gradually increasing in length, after about the middle of the arm being about as long as broad, and in the terminal portion half again as long as broad; the great eversion of the brachials gradually dies away as the joints become oblong, giving place to a slight prominence of the distal edge of the brachials, which in the terminal portion of the arm becomes a rather strong overlap. Syzygies occur between the second and third or third and fourth brachials (more rarely between the fourth and fifth), again between the fifteenth and sixteenth to thirty-first and thirty-second (usually in the vicinity of the twentieth), and distally at intervals of from four to nineteen oblique muscular articulations, the interval being long in the proximal; short in the distal part of the arm.

The pinnules are in general like those of *H. naresianus*.

*Type-specimen*.—Cat. No. - $\frac{1}{4}$ -, Indian Museum; lat.  $13^{\circ} 47' 49''$  N., long.  $73^{\circ} 07' 00''$  E.; 636 fathoms.

*Cotype*.—Cat. No. 25487, U.S.N.M.; from the same locality.

This species is dedicated to Mr. Frank Springer, the eminent authority on the Crinoidea.

#### HYPALOCRINUS ORNATUS, new species.

In general like *H. springeri*, but a smaller and more delicate species.

Stem as in *H. springeri*, but only 3 mm. in diameter; cirri proportionately more slender, 30 mm. long (ten times the stem diameter) with 40 joints, the dorsal tubercles commencing at about the seventeenth; basals as in *Isocrinus decorus*, without ornamentation; radials without dorsal ornamentation, but with the distal edges everted and produced into a high, thin, scalloped overlapping ridge; IIBr 4 (3+4).

Eighteen to twenty arms, about 95 mm. long from the radials.

*Type-specimen*.—Cat. No.  $\frac{35}{6} \frac{24}{4}$ , Indian Museum; Andaman Sea; 200 fathoms.

*Cotype*.—Cat. No. 25488, U.S.N.M.; from the same locality.





# DRAGONFLIES OF THE MISSISSIPPI VALLEY COLLECTED DURING THE PEARL MUSSEL INVESTIGATIONS ON THE MISSISSIPPI RIVER, JULY AND AUGUST, 1907.

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## INTRODUCTION.

Many opportunities were afforded for the collection of dragonflies in connection with the pearl mussel investigations on the Mississippi River and its tributaries during the summer of 1907. So far as practicable these opportunities were improved and a list is here presented of the different species obtained, with their geographic and seasonal distribution. Some of the territory visited had been previously worked over by dragonfly investigators in a more thorough and satisfactory manner, but much of it also was new and is here reported upon for the first time.

Then, too, all the previous work had been disconnected, confined to a single State or even a single locality, and hence there was not the same chance for correlation and comparison.

The present is the first attempt, so far as known, to collect from any considerable extent of the Mississippi River and its tributaries; and while it is confessedly deficient in many particulars, it nevertheless affords a general outlook that may be of some value. The itinerary of the trip, so far as dragonfly collecting was concerned, was as follows:

The time between July 6 and 12 was spent at St. Paul in examining some of the numerous small lakes with which that city and Minneapolis are surrounded. Leaving St. Paul on the 12th, a run was made down the Mississippi to Prescott, Wisconsin, where the party remained until the 15th. On that date the St. Croix River was ascended as far as Stillwater, Minnesota, where a stop of twenty-four hours was made, during which time dragonflies were collected from both banks of the river and from a small lake in the outskirts of the town. Returning to Prescott the next forenoon and continuing down the Mississippi, the party stopped at La Crosse, Wisconsin.

from the 20th to the 22d, and reached McGregor and Prairie du Chien on the 25th.

From Prairie du Chien on the 26th the Wisconsin and Kickapoo rivers were ascended as far as Wauzeka, where the banks of the Kickapoo and the marshy land adjacent to them were thoroughly examined for dragonflies. A return was made to McGregor the same afternoon. Again continuing down the Mississippi, the party stopped at Muscatine, Iowa, for twenty-four hours and reached Burlington in the same State on August 3. Here a stop was made until the 6th, and again both banks of the river were thoroughly examined for specimens.

From Burlington the Mississippi was descended to Grafton, Illinois, which was reached on the 11th. On the 12th the Illinois River was ascended as far as Hardin, Illinois, and a return was made on the 13th, collecting along both banks.

On the 13th also a run was made down the Mississippi to the mouth of the Missouri River, which was ascended for a few miles and back again, the party reaching St. Louis on the evening of the 13th. Leaving there the morning of the 14th, a long run was made down the Mississippi to Cairo, Illinois, at the mouth of the Ohio River, which was reached on the 19th.

During this entire run not a solitary dragonfly was seen except one or two specimens of *Libellula pulchella* Drury flying across the river.

The Ohio was then ascended on the 20th to Paducah, Kentucky, at the mouth of the Tennessee River. The next day the party started up the Tennessee and reached Riverton, Alabama, on the 24th. Here a stop was made till the 26th and considerable collecting was done. We started back down the river on the 26th for Paducah, where the trip ended on August 30.

The Mississippi River was thus covered from St. Paul to Cairo through the States of Minnesota, Wisconsin, Iowa, Missouri, and Illinois, and there were included also 40 miles of the St. Croix River, 20 miles of the Wisconsin and Kickapoo rivers, and 40 miles of the Illinois River. The Ohio River was then covered from Cairo to Paducah, between the States of Illinois and Kentucky, and the Tennessee River through the States of Kentucky and Tennessee into Alabama, making in all a distance of nearly 2,000 miles.

With the exception of a partial duplicate series, which the author was kindly allowed to retain and for which his sincere thanks are tendered to the honorable Commissioner of the Bureau of Fisheries, all the specimens collected are now in the U. S. National Museum and admit of ready reference.

A few notes descriptive of the general physical characteristics are given under such of the localities as seem to demand them. Where

they are omitted it is to be understood that the conditions were those usually found along the river—high and heavily wooded banks with a cleared area at the immediate margin of the river, more or less covered with tall grass and weeds.

#### LIST OF SPECIES.

##### I. LAKE AMELIA, MINNEAPOLIS, MINNESOTA, JULY 6 AND 7.

This is a small lake west of Minneapolis which serves as one of the feeders of the Minnehaha River. It is surrounded by high and dry banks which are entirely cleared, leaving only here and there a bush or tree. The immediate shores are covered with a dense growth of grass and weeds, back of which are cultivated fields.

1. *ANAX JUNIUS* (Drury).

Common around the shore and inland half a mile or so; a very strong flier and hard to capture except when mating.

2. *TETRAGONEURIA SPINIGERA* (Selys).

Common flying along the shore and very close to it inland; frequently alights and can then be easily captured.

3. *LIBELLULA PULCHELLA* Drury.

Common not merely around the lake but far inland over the potato and corn fields; too wary to be easily caught.

4. *LIBELLULA EXUSTA* Say.

A single male captured near the shore, the dorsal surface of whose abdomen was already (July 6) deeply pruinose.

5. *GOMPHUS SPICATUS* Hagen.

A single male captured in the grass along shore; no others seen, although carefully searched for.

6. *LEUCORHINIA INTACTA* (Hagen).

Abundant everywhere along shore and for some distance inland.

7. *CALOPTERYX MACULATA* (Beauvois).

Found in the gorge of the Minnehaha River, the outlet of Lake Amelia, below the falls; fairly common.

8. *CALOPTERYX ÆQUABILIS* Say.

Found in the same gorge, but not as common as *C. maculata*.

9. *LESTES INEQUALIS* Walsh.

Two specimens seen and one captured; not common.

10. *LESTES UNCATUS* Kirby.

A single male captured in the grass near the shore.

11. *ISCHNURA VERTICALIS* (Say).

Fairly common in the grass alongside the lake; only orange females found, no black one.

12. *ENALLAGMA EBRIUM* (Hagen).

Found in company with the preceding species everywhere, even at a distance from the lake shore in the woods and cultivated fields; females as common as the males.

13. *ENALLAGMA HAGENI* (Walsh).

Found everywhere, fairly swarming in the grass along shore and for some distance inland; eaten by *Gomphus spicatus*.

## II. LAKE PHALEN, ST. PAUL, MINNESOTA, JULY 8.

This is a small lake northeast of St. Paul and partially outside the city limits. Its western and northern shores are covered with primeval woods, while the southern and eastern banks are low and swampy in places and clothed with dense underbrush. At the northwest corner the lake is connected with another much smaller lake or pond by a short stream which winds through an intervening strip of low marshy ground.

The banks of the smaller pond are densely wooded, except a narrow strip along the shore and around the outlet.

On the stream connecting the two bodies of water and around the shores of the smaller pond the dragonflies were especially abundant, and most of the species recorded were collected there.

The species of *Tetragoneuria* was the one most abundant on Lake Phalen itself.

1. *ANAX JUNIUS* (Drury).

Fairly common around the shore; several seen closely enough for satisfactory identification, but none captured.

2. *ÆSHNA JUNCEA VERTICALIS* (Hagen).

Fairly common; a female caught off the side of the trolley car just as it stopped; body very beautifully colored when alive, but fades almost immediately after death; actively feeding along the shore rather than over the water.

3. *LIBELLULA PULCHELLA* Drury.

Very common; sexes about equally abundant; two females captured by hand, which had evidently recently emerged from their pupa cases.

4. *LIBELLULA QUADRIMACULATA* Linnaeus.

Two females secured along the shore; the only ones seen.

5. *CELITHEMIS EPONINA* (Drury).

A single pair captured, which were the only ones seen.

6. *GOMPHUS VILLOSIPES* Selys.

Common, squatting on the bare ground, logs, and rocks; found in company with *G. spicatus*, but is considerably larger; strong and pugnacious, catches and eats the smaller dragonflies like *Leucorhinia* and *Sympetrum*.

7. *GOMPHUS SPICATUS* Hagen.

Three captured, all females; smaller than preceding but habits similar; feeds largely on damselflies, like *Enallagma* and *Ischnura*.

8. *TETRAGONEURIA CYNOSURA* (Say).

Common everywhere; all secured were males; hovers over the water but rarely alights; very pugnacious, attacking and driving away *Gomphus* and even *Æshna*. No *spinigera* seen at this lake, no *cynosura* at Lake Amelia.

9. *ERYTHEMIS SIMPLICICOLLIS* (Say).

Two pairs secured, both sexes in full color and not yet beginning to become pruinose.

10. *LEUCORHINIA INTACTA* (Hagen).

Common everywhere, the sexes about even in numbers.



11. *LEUCORHINIA PROXIMA* Calvert or *FRIGIDA* Hagen.

Both sexes secured. Males with yellow spots along the back of the thorax and the first five abdominal segments; seventh, eighth, and ninth segments much dilated; two large yellow spots on the ventral surface of second segment; lower appendages fused with a much shallower notch between them than in *intacta*. Females with the basal half of the wings, or at least to the inclosing of the triangle, colored red; dorsal yellow spots like the male but not as distinct; ventral surface of second to seventh segments becoming pruinose.

12. *SYMPETRUM RUBICUNDULUM* (Say).

A single pair secured; no others seen; easily distinguished even at a distance by its brilliant red color.

13. *ENALLAGMA SIGNATUM* (Hagen).

Quite common flying about the floating algae.

14. *ENALLAGMA CARUNCULATUM* Morse.

Fairly common, but not as plentiful as *E. ebrium* and *E. hageni*.

15. *ENALLAGMA EBRIUM* (Hagen).

Both sexes very common in the grass along shore.

16. *ENALLAGMA HAGENI* (Walsh).

Most common of all the damselflies; both sexes found everywhere in the grass and weeds along shore.

17. *ENALLAGMA ANTENNATUM* (Say).

Rare, only a few seen; found on rushes over the water.

18. *ISCHNURA VERTICALIS* (Say).

Quite common in company with *Enallagma hageni*; both sexes secured.

19. *LESTES INEQUALIS* Walsh.

Rare, only a single female secured.

20. *LESTES VIGILAX* Hagen.

A little more numerous than *L. inequalis*; mostly males.

## III. BEAVER LAKE, ST. PAUL, MINNESOTA, JULY 10.

Nearly east from St. Paul, a small lake with a portion of the banks high and sandy and a portion low and swampy, everywhere covered with a dense growth of vegetation, underbrush, weeds, and grass. The two dragonflies which were most abundant were found on the high sandy banks, while the damselflies were captured in the low and wet places.

1. *LIBELLULA EXUSTA* Say.

Abundant everywhere, most common with *quadrimaculata* in the undergrowth close to the shore. When it alights it squats like a *Gomphus* on the rocks, stumps, and even on the ground. It is gregarious, as many as fifteen or twenty alighting on the same spot; it is also inquisitive and many were caught that actually alighted inside the net as it was being carried. The males are predominant and are all pruinose thus early, even the two antehumeral stripes showing clear white.

2. *LIBELLULA QUADRIMACULATA* Linnaeus.

Everywhere in company with the preceding; when it alights it does not squat but perches on a twig, holding its body horizontal even if the twig is vertical. It is gregarious, like the preceding species, from

twelve to fifteen or twenty alighting on the same stalk or twig. It is not wary, but neither is it inquisitive like the preceding species. These two species of the genus were present in great numbers, the others but sparingly.

3. *LIBELLULA PULCHELLA* Drury.

Only a few seen and none of them secured.

4. *LIBELLULA LUCTUOSA* Burmeister.

Two females secured in fine color.

5. *ANAX JUNIUS* (Drury).

A single pair secured close to the shore.

6. *TETRAGONEURIA SPINIGERA* (Selys).

Common everywhere, but not in great numbers like *Libellula exusta* and *L. quadrimaculata*.

7. *LEUCORHINIA INTACTA* (Hagen).

Common, but in small numbers; at Curve Lake, which is badly polluted by drainage from some harvester works in the immediate vicinity, this was the only dragonfly to be seen.

8. *LEUCORHINIA PROXIMA* Calvert, or *FRIGIDA* Hagen.

This is the same species as was found at Lake Amelia; only a few specimens were seen, and these were all secured.

9. *ENALLAGMA HAGENI* (Walsh).

Very common; hundreds secured by a single sweep of the net through the long grass along shore.

10. *ENALLAGMA EBRIUM* (Hagen).

Not as common as the preceding; about in the proportion of one to ten.

11. *NEHALENNIA IRENE* (Hagen).

Both sexes fairly common, but not in such numbers as *Ischnura posita*.

12. *ISCHNURA POSITA* (Hagen).

Found in company with *Enallagma hageni* and *E. ebrium* everywhere; not as plentiful as the former, but more so than the latter.

IV. MISSISSIPPI RIVER, BETWEEN ST. PAUL AND HASTINGS, JULY 12.

1. *LIBELLULA PULCHELLA* Drury.

Not common; only a few seen flying across the river.

2. *LIBELLULA QUADRIMACULATA* Linnæus.

Common on the bluffs on the east bank of the river; both sexes secured.

3. *LIBELLULA LUCTUOSA* Burmeister.

Both sexes captured upon the same bluff on which *L. quadrimaculata* was taken.

4. *PLATHEMIS LYDIA* (Drury).

Not common, only two specimens secured, both females.

5. *GOMPHUS FRATERNUS* (Say).

A couple of males were secured from the river bank just below St. Paul.

6. *LEUCORHINIA INTACTA* (Hagen).

Common everywhere along both banks of the river.

7. *LEUCORHINIA PROXIMA* Calvert or *FRIGIDA* Hagen.

The same species as previously recorded, obtained from the bluffs along the east side of the river.

8. *TETRAGONEURIA CYNOSURA* (Say).

Common everywhere, flying over the water and along the banks.

9. *TETRAGONEURIA SPINIGERA* (Selys).

As common as the preceding; some dead ones seen floating in the water, with fish jumping for them.

10. *ARGIA APICALIS* (Say).

Both sexes found around the heaps of clam shells on the east bank of the river near Pleasant Farms.

11. *ARGIA MÆSTA PUTRIDA* (Hagen).

Both sexes found in company with *A. apicalis*.

12. *ÆSHNA JUNCEA VERTICALIS* (Hagen).

Many seen flying across the river and along the east bank.

13. *ANAX JUNIUS* (Drury).

Many seen flying across the river and along both banks.

It was noted that the species of *Tetragoneuria* mated most often during the hour preceding sunset. Many couples could then be seen flying over the water, and they would approach the boat and even alight on it. *Gomphus*, *Anax*, and *Æshna* were each seen plunging into the water after insects. *Anax* went in like a kingfisher, submerging its whole body and evidently grasping the insect with its feet. None of them apparently wet its wings while doing this, at least not enough to hinder it at all in its flight.

## V. PRESCOTT, WISCONSIN, JULY 13 TO 15.

1. *LIBELLULA PULCHELLA* Drury.

Not common, only a few seen flying across the river.

2. *LIBELLULA QUADRIMACULATA* Linnæus.

Only four individuals of this species seen.

3. *ÆSHNA CONSTRICTA* Say.

Common flying about in the woods near the St. Croix River; four females secured. It alights on the sides of tree trunks or hangs vertically downward from the underside of a twig or a leaf, and in this position quietly munches the insect it has secured. It is more active toward night, coming out of the woods and flying about over the water.

4. *GOMPHUS VASTUS* Walsh.

Common on the rocks along the shore of the river; all that were secured proved to be males.

5. *GOMPHUS FRATERNUS* (Say).

Not as common as *G. vastus*; the two that were secured were females.

6. *DIDYMOPS TRANSVERSA* (Say).

Two males caught in the woods along shore, others seen but only in a single restricted locality.

7. *ARGIA MÆSTA PUTRIDA* (Hagen).

Both sexes common along the rocky shore close to the water.

8. *ARGIA VIOLACEA* (Hagen).

Both sexes common in company with *A. mæsta putrida*.

9. *LESTES RECTANGULARIS* Say.

Three males taken in the grass along the banks some distance from the water, where it was shady; four other males were taken along a slough on the opposite side of the river.

10. *GOMPHUS EXTERNUS* Selys.

A single male taken on the river bank in front of the town.

11. *LIBELLULA LUCTUOSA* Burmeister.  
Both sexes found at a small pond south of the town.
12. *PLATHEMIS LYDIA* (Drury).  
Both sexes found at the same pond with *Libellula luctuosa*.
13. *CALOPTERYX ÆQUABILIS* Say.  
A single pair seen in the slough opposite Prescott.
14. *HETÆRINA AMERICANA* (Fabricius).  
A single specimen seen on the island opposite the town.
15. *ENALLAGMA HAGENI* (Walsh).  
Sparsely scattered along the river's edge.
16. *ENALLAGMA EBRIUM* (Hagen).  
A few found with *E. hageni*.

## VI. STILLWATER, MINNESOTA, JULY 15.

On the St. Croix River; the banks of the river are high and dry and well wooded, except an area just opposite the town where formerly stood a large sawmill. The refuse accumulating from this mill has formed a terrace along the river's edge elevated well above the water and without a shred of vegetation anywhere upon it.

1. *LIBELLULA QUADRIMACULATA* Linnæus.  
Found by the hundreds in the old lumber yard on the bank of the St. Croix opposite Stillwater; every stick, stub, and bush alive with them. They were very tame, alighting not merely on the net but also on the hand and arm and all over the clothing. This and the other four species here listed were the only dragonflies seen.
2. *LEUCORHINIA INTACTA* (Hagen).  
Common, but not nearly as numerous as *Libellula quadrimaculata*.
3. *ARGIA TIBIALIS* (Rambur).  
Both sexes flying about in the open sunshine in company with *Libellula quadrimaculata* and *Leucorhinia intacta*.
4. *ARGIA APICALIS* (Say).  
A few males found in company with *A. tibialis*.
5. *PLATHEMIS LYDIA* (Drury).  
Both sexes found on the river bank a little below the lumber yard.

## VII. LILY LAKE, STILLWATER, MINNESOTA, JULY 16.

A small sheet of water on the high ground to the west of the town; its western and northern banks are covered by dense underbrush, the eastern and southern banks cleared and occupied by dwellings. From the southeast corner proceeds a small outlet, winding about through soft, marshy land. The dragonflies were most abundant along this outlet and on the margin of the lake in its immediate vicinity.

1. *EPICORDULIA PRINCEPS* (Hagen).  
A few seen patrolling the shore; one male captured.
2. *LIBELLULA LUCTUOSA* Burmeister.  
Both sexes quite plentiful in one restricted area at the northwest corner of the lake.
3. *LIBELLULA PULCHELLA* Drury.  
Common, many of the females just out of their pupa cases.



4. *ERYTHEMIS SIMPLICICOLLIS* (Say).

Common everywhere.

5. *PLATHEMIS LYDIA* (Drury).

Fairly common, many of the females just emerged from their pupa cases.

6. *LEUCORHINIA INTACTA* (Hagen).

Common everywhere; the most numerous species seen.

7. *TETRAGONEURIA SPINIGERA* (Selys).

A single female taken and one or two others seen.

8. *DOROCORDULIA LIBERA* (Selys).

Several seen flying about over the small stream which serves as the outlet to the lake; distinguished readily by its inflated abdomen; hard to catch, but both sexes secured.

9. *LIBELLULA QUADRIMACULATA* Linnæus.

Found in company with *Dorocordulia libera* and quite common; but it is very wary here, and it was extremely difficult to secure even a single specimen.

VIII. RED WING, MINNESOTA, JULY 17.

1. *LIBELLULA PULCHELLA* Drury.

Several seen flying across the river.

2. *ANAX JUNIUS* (Drury).

Many seen patrolling the river banks.

3. *PLATHEMIS LYDIA* (Drury).

Both sexes seen along the river bank just above town.

4. *GOMPHUS EXTERNUS* Selys.

A single pair captured on the river bank.

5. *GOMPHUS VASTUS* Walsh.

Common everywhere; most of the specimens secured were males.

6. *GOMPHUS CRASSUS* Hagen.

A single female secured in company with *G. vastus*.

7. *GOMPHUS FRATERNUS* (Say).

Both sexes fairly common.

8. *GOMPHUS AMNICOLA* Walsh.

A single female secured in company with *G. fraternus*.

9. *LESTES INEQUALIS* Walsh.

Both sexes common in shady places near the woods.

10. *ARGIA TIBIALIS* (Rambur).

Both sexes common along the river bank.

11. *ARGIA APICALIS* (Say).

Found in company with *A. tibialis*, but not as plentiful.

12. *ARGIA MÆSTA PUTRIDA* (Hagen).

A few individuals found along the river bank.

13. *ENALLAGMA HAGENI* (Walsh).

Found in the grass along the river bank.

14. *ENALLAGMA EBRIUM* (Hagen).

Found in company with *E. hageni*.

IX. WINONA, MINNESOTA, JULY 19.

1. *LIBELLULA PULCHELLA* Drury.

Several seen flying across the river.

2. *PLATHEMIS LYDIA* (Drury).

Both sexes taken along the river bank.

3. *ARGIA MÆSTA PUTRIDA* (Hagen).

A few in the open spaces close to the water's edge.

4. *ISCHNURA POSITA* (Hagen).

A few taken in company with *E. hageni* and *E. ebrium*.

5. *ENALLAGMA HAGENI* (Walsh).

Fairly common in the tall grass along the river banks.

6. *ENALLAGMA EBRIUM* (Hagen).

Found with *E. hageni*, but not so numerous.

## X. HOMER, MINNESOTA, JULY 20.

Very few dragonflies or damselflies seen; a few individuals of *Libellula pulchella* Drury, *Anax junius* (Drury), and *Plathemis lydia* (Drury) observed flying across the river. *Lestes vigilax* Hagen, *L. rectangularis* Say, and *Argia moesta putrida* (Hagen) taken in small numbers along the river banks.

## XI. REEDS LANDING, MINNESOTA, JULY 18.

1. *ANAX JUNIUS* (Drury).

Common patrolling the shore or flying over the water.

2. *GOMPHUS FRATERNUS* (Say).

Both sexes captured along the sandy shores.

3. *GOMPHUS VASTUS* Walsh.

More specimens, including both sexes, of this species were here secured than at any other locality on the river; the banks of the river with alternating reaches of sand and gravel seemed peculiarly attractive to these dragonflies.

4. *SYMPETRUM ALBIFRONS* (Charpentier).

Both sexes were captured in the tall weeds along the edge of the woods; they seem to prefer shady spots.

5. *SYMPETRUM RUBICUNDULUM* (Say).

A single male was found in company with *S. albifrons*.

6. *CALOPTERYX MACULATA* (Beauvois).

Both sexes common along the steep banks where the grass reaches to the water's edge and there is a swift current.

7. *CALOPTERYX ÆQUABILIS* Say.

Both sexes of this damselfly were found in company with *C. maculata*, but were not so numerous.

8. *LESTES VIGILAX* Hagen.

Both sexes found in the tall weeds and grass back from the water; not very common.

9. *LESTES RECTANGULARIS* Say.

Both sexes secured in company with *L. vigilax*.

10. *ARGIA MÆSTA PUTRIDA* (Hagen).

A few specimens seen along the river banks.

## XII. LA CROSSE, WISCONSIN, JULY 20 TO 22.

Just to the north of the city the banks of the Mississippi are low and swampy and traversed by numerous streams and bayous. The

railroad tracks cross and recross this region in many directions and afford a convenient means of reaching localities that would otherwise be inaccessible. Much of the collecting was done along these railroad tracks.

1. *LIBELLULA PULCHELLA* Drury.

Common everywhere around the outskirts of the town.

2. *PLATHEMIS LYDIA* (Drury).

A single colony, including both sexes, of this species was discovered at a small pond just north of the railroad tracks; none was seen anywhere else.

3. *ANAX JUNIUS* (Drury).

Very common over the marshes and along the La Crosse River above the city.

4. *EPICORDULIA PRINCEPS* (Hagen).

A few seen patrolling the banks of the La Crosse River.

5. *SYMPETRUM RUBICUNDULUM* (Say).

A few individuals secured in the edge of the woods back of the railroad tracks.

6. *GOMPHUS FRATERNUS* (Say).

Both sexes captured on the gravel along the river bank.

7. *GOMPHUS VASTUS* Walsh.

In company with *G. fraternus* and more numerous.

8. *PERITHEMIS DOMITIA* (Drury).

Both sexes obtained at the lake in the park.

9. *ENALLAGMA HAGENI* (Walsh), *E. EBRIUM* (Hagen), and *E. SIGNATUM* (Hagen).

Found together in the long grass and weeds along the river bank; the first-named species the most abundant.

10. *LESTES RECTANGULARIS* Say and *L. VIGILAX* Hagen.

Found a little distance back from the water, near the woods.

11. *ARGIA MÆSTA PUTRIDA* (Hagen) and *A. APICALIS* (Say).

Found in the shrubbery along the water's edge, the last mentioned the most abundant species.

12. *ISCHNURA VERTICALIS* (Say).

A few found in company with the species of *Enallagma*.

XIII. BROWNSVILLE, WISCONSIN, JULY 23.

After leaving La Crosse the only Neuroptera seen were at Brownsville, Wisconsin, Crosby's Slough, Minnesota, and Victory, Wisconsin. At each of these places the high and wooded banks yielded three species of *Argia*, namely *mæsta putrida* (Hagen), *tibialis* (Rambur), and *apicalis* (Say), their relative abundance being in the order named.

Where the shores became sandy and less steep two species of *Gomphus*, *vastus* Walsh and *fraternus* (Say) were predominant, flying over the water and patrolling the banks. Apparently these two genera did not intermingle to any extent, but each was colonized by itself.

XIV. LANSING, IOWA, JULY 24.

Only two species of *Gomphus*, *vastus* Walsh, and *externus* Selys, were seen at this station or along the river above and below it.

## XV. PRAIRIE DU CHIEN, WISCONSIN, JULY 25.

Again only two species of dragonflies seen, *Gomphus externus* Selys, and *Plathemis lydia* (Drury); both of these were fairly common. The river banks were low, flat, and sandy, and in the scattered weeds were obtained *Argia tibialis* (Rambur), *A. apicalis* (Say), and *Ischnura verticalis* (Say), none of the three at all common.

## XVI. HORSESHOE LAKE, OPPOSITE MCGREGOR, IOWA, JULY 26.

Another excellent example of colonization, *Perithemis domitia* (Drury), was found here by the hundreds, the males out on the lily pads in the open lake, the females in the weeds along the shore. This species was seen at only a few other places, and then only sparingly. *Epicordulia princeps* (Hagen), and *Libellula pulchella* Drury were the only other dragonflies seen; the former were much the more numerous and were patrolling the pickerel weed and rushes along the shore. The lily pads and rushes were further tenanted by three species of *Enallagma*, *hageni* (Walsh), *ebrium* (Hagen), and *signatum* (Hagen), none of them at all numerous. In addition there were a few specimens of *Ischnura verticalis* (Say).

## XVII. WAUZEKA, WISCONSIN, JULY 26.

This was 15 miles up the Wisconsin River and a half mile up the Kickapoo River, on the banks of the latter. The ground was all marsh land, soggy and wet, with standing water everywhere. Here was found a colony of *Plathemis lydia* (Drury), both sexes of which were present in large numbers, flying about over the water. The only other dragonflies seen were *Gomphus externus* Selys, a pair of which were captured in one of the dry spots on the marshes, while others were seen flying over the water and along the flat, dry banks of the Wisconsin River. There were also a few males of *Perithemis domitia* (Drury) seen on the marshes, and *Libellula pulchella* Drury flying over the fields farther back from the water. Of the damselflies, *Heterina americana* (Fabricius) was found along the grassy banks of the Wisconsin River in limited numbers, while *Lestes vigilax* Hagen was found in the rushes on the marshes.

## XVIII. GUTTENBURG, IOWA, JULY 27.

Here was a flat, dry shore, raised considerably above the water and covered thickly with weeds. On it were found *Libellula luctuosa* Burmeister and *Gomphus externus* Selys, while flying about over the water were *Epicordulia princeps* (Hagen) and a few males of *Perithemis domitia* (Drury). Of damselflies there were found *Enallagma hageni* (Walsh), *Ischnura verticalis* (Say), and *Lestes rectangularis* Say.



## XIX. CLINTON, IOWA, JULY 30 AND 31.

From Guttenburg to Clinton the shore was dry and sandy and yielded nothing but *Argia tibialis* (Rambur) and *Argia apicalis* (Say), and the two species of *Gomphus*, *vastus* Walsh and *externus* Selys.

At Send Prairie, Illinois, the sand was raised in high bluffs along the shore, and here the two species of *Gomphus* were specially abundant. Elsewhere even the species of *Argia* were scarce and no other kinds were seen. At several of the landings just above Clinton not even a single specimen of dragonflies or damselflies could be found by careful and long-continued hunting. Taken all in all, this was the most barren section of the river encountered during the entire season, except that between St. Louis and Cairo.

## XX. LE CLAIRE, IOWA, JULY 30.

The shores at this place were high, dry, and sandy, and there were very few dragonflies or damselflies to be seen. *Epicordulia princeps* (Hagen), *Tetragoneuria cynosura* (Say), *Perithemis domitia* (Drury), and *Argia tibialis* (Rambur) comprised all that could be found, and of the first three only a single specimen was seen.

## XXI. MUSCATINE, IOWA, AUGUST 1.

Here the shore was low and covered with a rich growth of weeds, in which there was the greatest variety of dragonflies and damselflies, in the smallest space, of any locality on the river.

Only a few moments could be spent in collecting, but in that time 14 species were secured.

1. *ÆSHNA JUNCEA VERTICALIS* (Hagen).

Two specimens taken in the high bushes back from the shore.

2. *EPICORDULIA PRINCEPS* (Hagen).

A single specimen seen patrolling the river bank.

3. *LIBELLULA PULCHELLA* Drury.

Common everywhere along the banks and over the water.

4. *LIBELLULA LUCTUOSA* Burmeister.

A few males found in the weeds along shore.

5. *GOMPHUS AMNICOLA* Walsh.

A single pair captured on the rocks at the water's edge.

6. *ERYTHEMIS SIMPLICICOLLIS* (Say).

Males common on the river bank, but only a few females seen.

7. *PACHYDIPLAX LONGIPENNIS* (Burmeister).

A single specimen taken in the thick undergrowth.

8. *PERITHEMIS DOMITIA* (Drury).

A single female captured at the water's edge; no others seen.

9. *SYMPETRUM VICINUM* (Hagen).

Fairly common along the edge of the woods back from the river bank.

10. *ARGIA MÆSTA PUTRIDA* (Hagen).

Common everywhere in the dry and open places on the banks.

## 11. ARGIA TIBIALIS (Rambur).

Found in company with *A. mæsta putrida*, and about as common.

## 12. LESTES VIGILAX Hagen.

A single specimen taken in the thick weeds.

## 13. ISCHNURA VERTICALIS Say.

Also rare; a few specimens secured in a patch of long grass.

## 14. ENALLAGMA GEMINATUM Kellicott.

Rare; a few found in company with *I. verticalis*.

At a landing a couple of miles above the town on the river bank an hour's search revealed nothing but *Argia mæsta putrida*, and seemingly the locality was fully as favorable as this other one.

## XXII. BURLINGTON, IOWA, AUGUST 3 TO 6.

## 1. ANAX JUNIUS (Drury).

Several seen and one found mutilated on the shore.

## 2. ÆSHNA CLEPSYDRA Say.

A single male captured in the woods near the river.

## 3. TETRAGONEURIA CYNOSURA (Say).

Several seen along the water's edge.

## 4. LIBELLULA PULCHELLA Drury.

Common everywhere, particularly along the western bank of the river.

## 5. PLATHEMIS LYDIA (Drury).

Rare; only a few males seen.

## 6. GOMPHUS DESCRIPTUS Banks.

A couple of females secured on the rocks near the river.

## 7. ERYTHEMIS SIMPLICICOLLIS (Say).

Common on both banks near the water.

## 8. PERITHEMIS DOMITIA (Drury).

A single pair taken on the west bank.

## 9. PACHYDIPLAX LONGIPENNIS (Burmeister).

More common on the eastern bank of the river.

## 10. SYMPETRUM RUBICUNDULUM (Say).

Found in company with *Pachydiplax longipennis* on the eastern bank of the river.

## 11. ISCHNURA VERTICALIS (Say).

Common everywhere in the grass along the water's edge.

## 12. ARGIA TIBIALIS (Rambur).

Found in the more open places and very common.

## 13. ARGIA APICALIS (Say).

Found with *A. tibialis* and nearly as common.

## 14. ARGIA MÆSTA PUTRIDA (Hagen).

Common on the western bank, but none could be found on the eastern side; prefers the rocks and sand along the water's edge.

## 15. ENALLAGMA ANTENNATUM (Say).

A single male secured in company with *Ischnura*.

## 16. HETÆRINA AMERICANUA (Fabricius).

A single male was secured from O'Connell slough which had escaped from its pupa case so recently that its color was not yet defined.

There was no evidence of colonization here, but a fairly even distribution of all the species. Several individuals of *Libellula pul-*

*chella* Drury were observed going to roost for the night in the tall ironweed along a dried-up overflow bottom. When roosting they flatten back against the vertical stem of the weed instead of holding their bodies horizontal as is done when they alight in the daytime, possibly as a protection against rain. This was not the right kind of a shore for *Gomphus*, and hence only the single pair was seen.

## XXIII. QUINCY, ILLINOIS, AUGUST 9.

Only a half-hour could be spent here, and in that time the following species were either seen or secured: *Libellula pulchella* Drury, *Aeshna juncea verticalis* (Hagen), *Pachydiplax longipennis* (Burmeister), *Gomphus amnicola* Walsh, *Argia tibialis* (Rambur), and *A. mæsta putrida* (Hagen).

## XXIV. HANNIBAL, MISSOURI, AUGUST 10.

Two hours in the afternoon and the same period the next forenoon were spent here in collecting, but with limited results. There were hundreds of *Libellula pulchella* Drury flying across the river and over the inland fields, but the only other species found were *Gomphus externus* Selys, *G. amnicola* Walsh, *Pachydiplax longipennis* (Burmeister), *Argia mæsta putrida* (Hagen), *A. tibialis* (Rambur), and *A. apicalis* (Say), and of these there was only a single specimen of each of the first three.

## XXV. THE ILLINOIS RIVER, AUGUST 12.

In passing up the river from Grafton to Hardin two distinct colonies of *Erythemis simplicicollis* (Say) were found. The first was 10 miles above Grafton, where the east bank of the river was covered with hundreds of this species, including both sexes, while many were flying across the river.

The other colony was 4 miles farther up the river, at the head of an island. Here the island seemed to be the headquarters from which the dragonflies flew out in every direction.

Just below Coon Creek an abundance of *Libellula pulchella* Drury was observed, and they could be seen flying over the inland fields. Repeated observations seemed to indicate that in general the flight was from the shady to the sunny side of the river, from east to west in the forenoon and from west to east in the afternoon.

## XXVI. COON CREEK, ILLINOIS, AUGUST 12.

This was between the colony of *Libellula* and one of *Erythemis*, and there were found here, naturally, these two species, though in limited numbers, and beside them *Pachydiplax longipennis* (Burmeister), fully as numerous as either of the preceding, *Celithemis cponina* (Drury), *Tetragoneuria cynosura* (Say), and *Gomphus plagiatus* Selys.

Of damselflies there were the two species of *Argia*, *apicalis* (Say) and *tibialis* (Rambur).

XXVII. HARDIN, ILLINOIS, AUGUST 12 AND 13.

Here were found a few specimens each of *Libellula pulchella* Drury, *Tetragoneuria cynosura* (Say), *Anax junius* (Drury), and *Gomphus amnicola* Walsh, together with large numbers of *Ischnura verticalis* (Say), and a few males of *Enallagma piscinarium* Williamson.

XXVIII. MISSISSIPPI RIVER FROM GRAFTON TO CAIRO, ILLINOIS, AUGUST 13 TO 20.

No stops were made between Grafton and the mouth of the Missouri River, but the dragonflies and damselflies were as common as they had been and could be seen along either bank flying over the water or in the bushes. A run was made up the Missouri for 8 or 10 miles and back, but not a solitary dragonfly was seen, and this continued all the way down to Cairo.

Repeated landings were made and the banks diligently searched for specimens, but without finding even one. This abrupt demarkation is no doubt due to the muddy water poured in by the Missouri River. No dragonfly larva could rightly be expected to live in such a medium, and their absolute refusal is what might naturally be looked for.

XXIX. JOHNSONVILLE, TENNESSEE, AUGUST 21.

On ascending the Ohio River the dragonflies began to appear again, and were as numerous as ever on reaching Paducah, at the mouth of the Tennessee River. For the entire length of this latter river to Riverton, Alabama, *Gomphus* was particularly abundant and could be seen at all hours of the day flying over the water. The first stop for collecting was made at Johnsonville, and here were found *Libellula pulchella* Drury, *Macromia teniolata* Rambur, *Erythemis simplicicollis* (Say), *Pachydiplax longipennis* (Burmeister), *Plathemis lydia* (Drury), *Argia moesta putrida* (Hagen), *A. tibialis* (Rambur), *A. violacea* (Hagen).

The shore at this particular place was not suitable for *Gomphus*, and none was secured.

XXX. SAVANNAH, TENNESSEE, AUGUST 23.

Here the shores were favorable for *Gomphus* and three species were caught—*vastus* Walsh, *notatus* Rambur, and one undetermined. No other dragon flies seen.

XXXI. RIVERTON, ALABAMA, AUGUST 24 TO 26.

The banks of the river were high and dry, except in one place in the outskirts of the town, where were a few small swampy ponds.



Here were found large numbers of *Libellula pulchella* Drury with *Plathemis lydia* (Drury) and a species of *Macromia*.

Along the river bank *pulchella* was not as numerous, and there were associated with it *Erythemis simplicicollis* (Say), *Pachydiplax longipennis* (Burmeister), *Macromia taniolata* Rambur, *Gomphus vastus* Walsh, *G. notatus* Rambur, two species of *Heterina*, one of which was *americana* (Fabricius), *Argia tibialis* (Rambur), *Argia violacea* (Hagen), and a species of *Anax*, of which none could be obtained.

#### SUMMARY.

Certain facts must be kept in mind while endeavoring to summarize these observations.

1. With few exceptions the examination of each locality was confined to a period of only a few hours duration. Hence the species obtained would represent the fauna of the locality for that day only, and would give but few suggestions in reference to its fauna at other times, or to seasonal changes.

2. The dates for each of the localities examined were different. While this would have little practical influence for neighboring localities visited within a few days of each other, it would mean a great deal when the interval was increased to a month, or even two months.

3. There was a continual progress in the localities visited from Minnesota, one of the extreme Northern States, to Alabama, one of the extreme Southern. Hence the geographic changes would cause considerable differences in the fauna, irrespective of the seasonal changes, and by thus combining the two their separate influence would be much augmented.

In spite of these difficulties, however, there are certain conclusions which may be fairly drawn from the observations which have just been recorded.

1. A small fresh-water lake or pond, surrounded by shrubbery and vegetation, furnishes the ideal breeding place for dragonflies and damselflies, with which even such a river as the Mississippi, with its numerous sloughs and bayous, is scarcely worthy of comparison. The larvæ of these insects evidently prefer clean to muddy water as a medium in which to live; in witness whereof may be cited the fact that not a solitary specimen of the Neuroptera was seen on the Missouri River or on the Mississippi between the mouth of the Missouri and the mouth of the Ohio.

2. Only a single species was found in all the localities visited. This species, *Libellula pulchella* Drury, may therefore be taken as the most widely distributed in the Mississippi Valley, both geographically and seasonally. A close second was furnished by *Pachydiplax longipennis* (Burmeister), which appeared in nearly all the localities. Furthermore, neither of these species was found colonized anywhere.

3. The genus *Gomphus* is chiefly the guardian of the river. The species may be seen at all times of day patrolling the river's surface with tireless vigilance or squatting upon the shore and watching their surroundings intently, and woe betide the luckless insect that comes within their reach. All of the species observed are remarkably alike in their habits so that it is practically impossible to distinguish them until after they are caught. This genus also was found universally distributed and not colonized.

4. The other dragonflies and the damsels, on the contrary, were found in colonies, each made up of a few closely related species that harmonize well with one another and restricted in its area with fairly well-defined borders. A few of these colonies are worthy of special mention.

A. The first was at Beaver Lake in St. Paul and was made up of *Libellula exusta* Say and *L. quadrimaculata* Linnaeus for the dragonflies, and *Enallagma hageni* Walsh for the damsels. The lake is small and surrounded by a scattering growth of underbrush and rank grass. There were hundreds of the dragonflies among the bushes and shrubs, while the tufts of grass were so loaded with *Enallagma* that a single sweep of the net secured over two hundred. While other species were found, as given in the list, it was only after long and careful search and in such small numbers as to count for nothing beside the myriads of the three species mentioned.

B. Another colony was found on the bank of the St. Croix River, opposite Stillwater, Minnesota. Here had been formerly a large saw-mill, and the river bank for a long distance was packed with sawdust, bark, and edgings to the depth of several feet. Flying about over this area and alighting on the projecting sticks were swarms of *Libellula quadrimaculata* Linnaeus, sometimes a dozen or more on the same stick, and with them were numerous specimens of *Argia tibialis* (Rambur), particularly along some piles of old slabs back from the water. The most careful search revealed only three other species, and in such small numbers that they could only be regarded as stragglers.

C. A third colony was found in Horseshoe Lake, a part of the river surrounded on three sides by islands and opposite the town of McGregor, Iowa. This was a colony of *Perithemis domitia* (Drury), and *Epicordulia princeps* (Hagen), the former flying over the lily pads by the score, the latter patrolling the pickerel weeds and rushes along the shore. The only other dragonfly seen after long and careful search was *Libellula pulchella* Drury, which had evidently come across from the mainland.

D. Special mention should also be made of the two colonies of *Erythemis simplicicollis* (Say) observed on the Illinois River, one

10 miles above Grafton and the other 4 miles farther up the river. These have already been referred to on page 667.

This isolation of species into colonies prevailed throughout the entire length of the various rivers visited and in some of the small lakes. It is a very different condition from what is found in other lakes where fifteen or twenty species, or even more, can be secured in a single afternoon; witness Lake Amelia and Lake Phalen. It leads naturally to the next conclusion—

5. With the exception of such genera as *Gomphus* and *Anax* and such species as *Libellula pulchella* Drury, the individual range of any dragonfly or damselfly is in all probability very small.

The members of one of these colonies just noted are probably natives of the locality. They were born there, they spend their lives in hunting the insects that surround the water, they lay their eggs in the same water, and then die. Continued observation of such a colonized area for many years would doubtless reveal much that would be of interest in its bearing upon colonization in general, as well as upon the distribution of species.





## FOUR NEW SPECIES OF THE CRINOID GENUS RHIZOCRINUS.

By AUSTIN HOBART CLARK,

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In his report upon the stalked crinoids collected by the *Challenger*, Dr. P. H. Carpenter admitted only two recent species of the genus *Rhizocrinus*, *R. lofotensis*, and *R. rawsoni*. The former is credited with a geographical range extending from the Lofoten Islands and Nantucket (Mass.) southward to Uruguay, and with a bathymetric range of from 80 to 1,900 fathoms; the latter is said to inhabit the Atlantic coasts of southern Europe and northern Africa, and to occur among the outlying groups of islands and throughout the West Indies at depths of from 73 to 1,277 fathoms. The first record of *lofotensis* is, of course, the original description of Sars, in 1864, when the genus was founded; the first record of *rawsoni* (under the name *lofotensis*) is that published in 1870 by Fischer,<sup>a</sup> who had obtained specimens off Setuval, Portugal, this antedating by two years Sir Wyville Thomson's record of the *Porcupine* specimens, cited as the first by Carpenter.

In 1883 Professor Perrier had described a supposedly new crinoid which had been dredged by the *Travailleur* off Morocco under the name of *Democrinus parfaiti*. This new genus was strongly criticised by Carpenter, who placed the type-species under the synonymy of *Rhizocrinus rawsoni*, as understood by him. Two years later (a year after the publication of the *Challenger* report) Perrier described, under the name of *Ilyocrinus recuperatus*, a very remarkable species, in all essentials a *Bathyrinus*, but having separate basals. This was also subjected to severe criticism by Carpenter. In the next year Korotneff reported the discovery of a large species of "*Rhizocrinus*" in the Straits of Sunda, where it was easily obtainable before the eruption of Krakatoa.<sup>b</sup>

Aside from a few additional records by Rathbun, Köhler, Chun, Grieg, and Agassiz (the last proving to be a *Bathyrinus*), nothing

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<sup>a</sup> Actes de la Soc. linn. de Bordeaux, XXVII, p. 351.

<sup>b</sup> Bull. de l'acad. roy. de Belgique [3], XII, p. 558.

additional was learned in regard to this genus until 1907, when Professor Döderlein published his report on the stalked crinoids of the *Siboga* expedition. In this he includes two new species, one obtained by the German steamer *Valdivia* off east Africa, the other by the *Siboga* in the East Indies. The latter, *R. weberi*, is possibly the species recorded by Korotneff in 1886.

Doctor Carpenter considered both *Rhizocrinus lofotensis* and *R. rawsoni* extremely variable in all their characters, and so broad are the diagnoses he gives that there appear to be no hard and fast lines of division between them. This, taken in connection with the enormous geographic and bathymetric ranges of the two forms as understood by him, led me to believe that each of Carpenter's species was in reality a composite of several. This opinion was confirmed by an examination of several hundred specimens from the West Indies and Gulf of Mexico in the United States National Museum and in the Museum of Comparative Zoology at Cambridge.

*Rhizocrinus lofotensis* does not occur on the American side of the Atlantic, its place being taken, from Cape Cod to Florida, by *R. verrilli*, which differs in being somewhat larger, generally stouter, with a less expanded basal cone and much shorter columnars.

RHIZOCRINUS CONIFER, new species.

Basals separated by distinct sutures; calyx very long, conical, expanding evenly from the top of the stem, the diameter at the distal end of the radials about three times that at the distal (lower) end of the basals; length of the calyx six times the distal diameter of the basals and over twice the distal diameter of the radials; a more or less marked constriction at the level of the base or the middle of the radials. The length of the calyx from the top of the stem to the end of the radials is 11 mm.

Stem moderately stout, probably about 150 mm. long; in the type 80 mm. long to the end of the thirtieth columnar; first columnar very short and discoidal, second about four times as broad as long, third not quite twice as broad as long, fourth about one-third longer than broad, fifth about twice as long as broad, after the seventh or eighth becoming three times as long as broad; second to fourteenth or fifteenth slightly barrel shaped, then becoming more cylindrical, with very slightly swollen ends. The longest columnars are about 3 mm. long by 1 mm. in diameter.

The first brachials are trapezoidal, longer than their proximal width.

*Type-specimen*.—Cat. No. 22679, U.S.N.M.; from *Albatross* station No. 2756; off Ceará, Brazil; lat.  $3^{\circ} 22' 00''$  S., long.  $37^{\circ} 49' 00''$  W.; 417 fathoms; bottom temperature,  $40.5^{\circ}$  F.

## RHIZOCRINUS BREVIS, new species.

1888. *Rhizocrinus rawsoni* P. H. CARPENTER, *Challenger Reports*, XXVI, Zoology, p. 267, fig. 19; p. 262 (part); p. 263 (SS. *Investigator*, 15 miles N. by E. of Panama; 300 fathoms).

The two specimens figured by Carpenter, which were dredged by Capt. E. Cole, of the cable ship *Investigator*, off Colon (not Panama), appear to be well worthy of specific recognition. They are not merely an extreme variety of *rawsonii* as supposed by Carpenter, but represent a definite type, presenting valid characters.

The calyx may be described as very short, conical, the width at the distal ends of the radials twice that at the distal (lower) end of the basals, one-fifth greater than the length; the radials are slightly longer than to half again as long as broad; the basals are separated by sutures.

The stem is not figured; but it is probably much like that of *R. robustus*.

The two figured specimens (of which the one represented by figure 19A may be considered the type) are in the zoological department of the British Museum; two others are in the geological department of the same institution.

## RHIZOCRINUS SABÆ, new species.

Calyx four times as long as the diameter of the proximal part of the column, and about three times as long as the diameter across the radials; the basal cup is somewhat swollen, so that the greatest diameter of the calyx is between the topmost columnar and the radials, usually nearer the latter, instead of across the radials as usual; this diameter is one-fifth greater than that across the radials, and is 1.8 times the diameter of the upper part of the stem; basals separated by distinct sutures. The calyx measures 4.5 mm. in length from the top of the stem to the distal end of the radials.

Stem very stout, as in *R. rawsonii*, the longest columnars being 2.6 mm. long by 1.7 mm. broad, with a rather prominent constriction.

The arms resemble those of *R. rawsonii*, and are 19 mm. long from the radials.

*Type-specimen*.—Cat. No. 22700, U.S.N.M., from off Saba, 200 fathoms, taken by Capt. E. Cole, of the cable steamer *Investigator*.

## RHIZOCRINUS ROBUSTUS, new species.

Calyx conical, moderately long, expanding evenly from the distal portion of the basals to the radials; summit of stem proportionately small, causing the calyx to appear disproportionately large; calyx three-fifths to nine-tenths again as long as the diameter at the radials and about five times as long as the proximal diameter of the stem.



There is sometimes a slight constriction about the basals or radials, but more commonly none. The basals are separated by distinct sutures.

Stem in large specimens 190 mm. to 280 mm. in length, comparatively slender, with 74 to 106 joints, the longest of which are 1.6 to twice as long as broad, about 3 mm. long. The columnars are all approximately cylindrical, those in the proximal third showing a very slight tendency toward a barrel-like shape, the remainder to a slight central constriction, but neither is as marked as in the related species; the lowest 30 mm. or 40 mm. of the stem has the articulations more or less swollen and produced, this soon giving place to numerous fine radicular cirri and stout irregular branching roots.

*Type-specimen*.—Cat. No. 22680, U.S.N.M., from *Albatross* station No. 2401; Gulf of Mexico, off Pensacola, Fla.; lat.  $28^{\circ} 38' 30''$  N., long.  $85^{\circ} 52' 30''$  W.; 142 fathoms; green mud and broken shell.

*R. rawsonii* may be at once distinguished from any of the above species by its almost cylindrical calyx, which is twice as long as broad at the radials, the latter dimension being usually less than half again as great as the diameter of the proximal part of the stem.

The calyx of *R. parfaiti* (which is a perfectly valid species) is more inclined to conical in its shape; the diameter across the radials is twice that across the distal end of the basals, while the length is one and one-half times the breadth at the radials.<sup>a</sup>

The species of *Rhizocrinus* may be conveniently grouped as follows:

- (1) Basals anchylosed, without sutures: *R. lofotensis*, *R. verrilli*.
- (2) Basals always separated by distinct sutures.

(a) Stem comparatively slender, the longer columnars being at least twice as long as broad; calyx distinctly conical: *R. conifer*, *R. brevis*, *R. robustus*, *R. chuni*.

(b) Stem very stout, the longer columnars but little longer than broad; calyx approaching the cylindrical: *R. rawsoni*, *R. parfaiti*, *R. weberi*, *R. sabæ*.

Döderlein has found that the species of *Bathycrinus* are, like the species of *Rhizocrinus*, divisible into two groups, one with the basals anchylosed into a solid basal cup or ring, the other with the basals separated by suture. This was, however, known long ago, for Perrier's *Ilyocrinus recuperatus* is a species belonging to the latter group, and was the first species of it to be described. A very good figure of it was published by Perrier in his *Explorations sous-marines*, page 273, figure 193 (1886).

<sup>a</sup>The data are taken from the figure published by Professor Perrier in his *Explorations sous-marines* (1886).



DESCRIPTIONS OF TWO NEW SPECIES OF ELECTRIC  
RAYS, OF THE FAMILY NARCOBATIDÆ. FROM DEEP  
WATER OFF THE SOUTHERN ATLANTIC COAST OF  
THE UNITED STATES.

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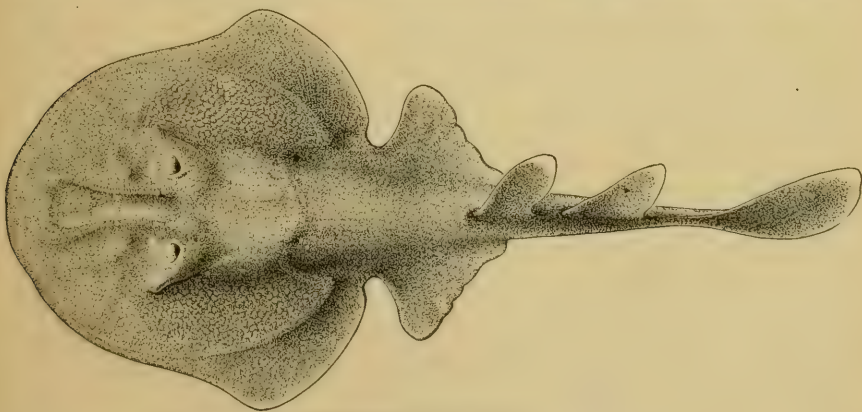
By BARTON A. BEAN and ALFRED C. WEED,  
*Of the Division of Fishes, U. S. National Museum.*

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In a lot of fishes collected by the steamer *Albatross* of the U. S. Bureau of Fisheries in deep water off the southern Atlantic coast of the United States were found two electric rays, with rudimentary (functionless) eyes, differing specifically one from the other and, likewise, from the only known species under the genus to which these are now assigned, namely *Benthobatis* Alcock.<sup>a</sup>

BENTHOBATIS MARCIDA Bean and Weed, new species.

Disk broadly ovate, body abruptly narrowed at the caudal edge of the pectoral fins so that the ventrals appear to be inserted entirely on



BENTHOBATIS MARCIDA.

the tail, which thus appears very long. The vent is just midway between tip of snout and end of caudal fin. The width across pectoral

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<sup>a</sup>Ann. and Mag. Nat. Hist., August, 1898, p. 144. Zool. of R. I. M. S. *Investigator*, Calcutta, 1899, p. 17, pl. xxvi, fig. 1. Type of the genus *Benthobatis moresbyi*.

fins is equal to the distance from tip of snout to caudal edge of these fins. The lax skin makes it difficult to see the true shape of the ventral fins. They appear to be less developed than in other members of the family. They are adnate to the tail their entire length and have the rays rather feebly developed. Two dorsal fins are developed, the second much larger than the first, the first dorsal inserted slightly in advance of the caudal edge of the ventrals; caudal large, obovate, with the dorsal edge nearly straight and the ventral edge obliquely rounded; tail with a very distinct lateral fold; eyes wanting or rudimentary, their position indicated by a pale spot situated  $1\frac{1}{2}$  cm. in front of the spiracles; teeth flat or concave, broadly rhombic with a small backward projecting point and arranged in quincunx; spiracles large, the edges not fringed or tuberculate; nasal valves confluent into quadrangular flap; a large electric organ developed between the head and pectoral fin on each side.

The skin over the entire body is very lax and flabby, making it difficult to see the true shape of the creature and take its measurements. The species is known from a single specimen, a female 49 cm. long, taken at station 2660 by the steamer *Albatross* of the Bureau of Fisheries, May 3, 1886, at a depth of 504 fathoms, in the course of an exploration of the eastern coast of the United States.

<i>Measurements.</i>		<i>Cm.</i>
Total length.....	( $19\frac{5}{16}$ in.)	49.0
Total length, without caudal.....		40.5
Tip of snout to end of ventrals.....		28.8
Tip of snout to end of pectorals.....		21.6
Tip of snout to origin of first dorsal.....		28.5
Tip of snout to origin of second dorsal.....		32.6
Tip of snout to spiracles.....		9.8
Tip of snout to nostrils.....		7.0
Tip of snout to first gill slits.....		12.0
Tip of snout to last gill slits.....		16.0
Tip of snout to mouth.....		8.7
Tip of snout to vent.....		24.5
Vent to end of caudal.....		24.5
Length of first dorsal base.....		2.8
Length of second dorsal base.....		4.0
Length of caudal.....		8.5
Diagonal height of first dorsal from origin to highest point.....		4.5
Diagonal height of second dorsal.....		6.5
Depth of caudal from highest point to horizontal projection of lowest part.....		6.0
Width across pectorals.....		21.5
Width across ventrals.....		14.0
Width between spiracles.....		4.3
Width between nostrils.....		3.8
Width of mouth.....		2.0
Width between first gill slits.....		5.3
Width between last gill slits.....		4.4
Length of opening of each gill slit about.....		1.0

Color of dorsal surface, light fawn-color, with a few scattered white spots about 1-2 mm. in diameter. The color becomes lighter toward the edges of the body and fades gradually into the dirty white of the belly.

*Type*.—Cat. No. 62916, U.S.N.M.

*Marcida*, loose, soft, lacking substance.

BENTHOBATIS CERVINA Bean and Weed, new species.

Disk considerably narrower than long, its width 2.5 cm. (one-sixth) less than the distance from tip of snout to end of pectoral fins; this is somewhat wider than is represented in the figure of *B. moresbyi*; length of disk slightly less than half of total length; eyes situated about 0.7 cm. in advance of the spiracles and much less reduced than in *B. moresbyi* and *B. marcida*; they may be slightly functional as the orbit seems to be somewhat developed; the external opening is about 1 mm. in length. Teeth rhombic, arranged in quin-cunx, occupying nearly the whole width of the jaw and each tooth has the surface flat or concave with a sharp point projecting backward.

Ventral fins about as represented in *B. moresbyi*; second dorsal much larger than the first and the caudal well developed evenly above and below with posterior margin rounded. In *B. moresbyi* the first dorsal is represented as being much larger than the second.

Nasal valves confluent, forming a quadrangular curtain; an electric battery on each side between head and pectoral fins.

Measurements.

	Cm.
Total length.....	33.0
	{ (13 in.)
Total length without caudal.....	27.5
Length to end of ventral fins.....	20.0
Length to end of pectoral fins.....	15.5
Length to origin of first dorsal.....	18.8
Length to origin of second dorsal.....	21.7
Length to spiracles.....	6.0
Length to nostrils.....	4.5
Length to first gill slit.....	7.8
Length to last gill slit.....	10.3
Length to mouth.....	5.3
Length to vent.....	16.3
Vent to end of caudal.....	16.7
Width across pectorals.....	13.0
Width across ventrals.....	9.8
Width between spiracles.....	2.6
Width between nostrils.....	2.5
Width of mouth.....	1.5
Width between first gill slits.....	4.5
Width between last gill slits.....	3.5
Length of gill slits about.....	0.6
Length of first dorsal base.....	1.6

	<i>Cm.</i>
Length of second dorsal base.....	2.9
Length of caudal.....	5.5
Depth of caudal.....	2.7
Diagonal height of first dorsal.....	2.5
Diagonal height of second dorsal.....	3.5

*Color*.—Upper surface light fawn color, fading at the edges into the dirty white of the belly; a few white spots scattered over the upper surface of the body; these are much less prominent than described in *B. moresbyi*.

Entire body and fins, except the caudal, enveloped in a loose flabby skin.

This species is well differentiated from *B. moresbyi* by the difference in color, greater width of disk, difference in relative size of dorsal fins, and in the greater development of the eyes, which may be due to the less depth of water in which it lives.

This species is known from a single specimen, a female 33 cm. (13 inches) long, from station 2664, steamer *Albatross*, of the U. S. Bureau of Fisheries, lat. 29° 41' N., long. 79° 55' W., depth 373 fathoms; bottom coral sand. Collected May 4, 1886.

*Type*.—Cat. No. 62917, U.S.N.M.

*Cervina*, like a deer, from the fawn color.

We would acknowledge our indebtedness to Dr. Theodore N. Gill for helpful suggestions in the preparation of these descriptions.



# INDEX.

	Page.
<i>Abudefduf rex</i> .....	601
<i>richardsoni</i> .....	600
<i>Acanthoniscus</i> .....	432
<i>spiniger</i> .....	431, 432, 434
<i>Acanthoniscus spiniger</i> Kinahan re- scribed.—The Isopod Crustacean, by Har- riet Richardson.....	431
<i>Acanthopneuste borealis</i> .....	472
Acridinæ of Authors.—On Brazilian Grass- hoppers of the Subfamilies Pyrgomorphinæ and Locustinæ, by James A. G. Rehn.....	109
<i>Acridium</i> .....	536
<i>tarsatum</i> .....	134
<i>Acrocheilus alutaceus</i> .....	427
<i>Acrydium flavo-fasciatum</i> .....	157, 158
<i>Actinometra</i> .....	361, 494, 497, 498
<i>borneensis</i> .....	392
<i>coppingeri</i> .....	392
<i>lineata</i> .....	494
<i>nigra</i> .....	506
<i>parvicirra</i> .....	507
<i>sentosa</i> .....	503
<i>Actitis hypoleucos</i> .....	464
<i>Actoniscus ellipticus</i> .....	378
<i>tuberculatus</i> .....	377
Additional Notes on Mammals of the Rho- Linga Archipelago, with Descriptions of New Species and a Revised List, by M. W. Lyon, jr.....	479
Additions to the List of Philippine Birds, with Descriptions of New and Rare Species, by E. A. Mearns.....	435
<i>Ægialitis alexandrina</i> .....	464
<i>dubia</i> .....	464
<i>Ægithina viridis</i> .....	475
<i>Æolacris</i> .....	114
<i>bella</i> .....	114
<i>caternaulti</i> .....	114
<i>octomaculata</i> .....	114
<i>Æshna clepsydra</i> .....	666
<i>constricta</i> .....	659
<i>juncea verticalis</i> .....	656, 659, 665, 667
<i>Æthiopsar cristatellus</i> .....	475
<i>Alauda wattersi</i> .....	474
<i>Alcedo bengalensis</i> .....	466
<i>Alecto</i> .....	494, 498, 506
<i>echinoptera</i> .....	498
<i>multifida</i> .....	392, 506
<i>Aleuas</i> .....	144
<i>vitticollis</i> .....	144
<i>Algete</i> .....	109
<i>brunneri</i> .....	109
<i>marginata</i> .....	414

	Page.
<i>Allodape philippinensis</i> .....	414
<i>Allosaurus</i> .....	299
<i>Allotheria</i> .....	623
<i>Alpheus dentipes</i> .....	20
<i>leviusculus</i> .....	1, 10, 21
<i>longicarpus</i> .....	2
<i>minus</i> .....	1, 2, 43
<i>paralecyone</i> .....	83
<i>precox</i> .....	3
<i>sauleyi</i> .....	1, 2, 52
<i>brevicarpus</i> .....	1, 2, 50
<i>longicarpus</i> .....	1, 2, 53
<i>spinifrons</i> .....	1
<i>tridentulatus</i> .....	1
America; with a Note on the Species of White- fish.—Descriptions of Three New Species of Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the Great Lakes of, by David Starr Jordan and B. W. Evermann.....	165
American Jurassic Crinoid.—A New, by Frank Springer.....	179
American Species of Snapping Shrimps of the Genus <i>Synalpheus</i> , by Henri Cou- tière.....	1
<i>Ammodiscoides</i> , a New Genus of Arenaceous Foraminifera, by Joseph A. Cushman.....	423
<i>Ammodiscoides</i> .....	424
<i>turbinatus</i> .....	424
<i>Ammodiscus</i> .....	424
<i>incertus</i> .....	423
<i>tenuis</i> .....	423
<i>Amorgius americanum</i> .....	561
<i>Amphimetra</i> .....	635
<i>discoidea</i> .....	403
<i>mortenseni</i> .....	635
<i>Anabrus</i> .....	534
<i>simplex</i> .....	537, 539, 555, 557
<i>Anallagma ebrium</i> .....	655
<i>Anax junius</i> ... 655, 656, 658, 659, 661, 662, 663, 666, 668	
<i>Ancinidiæ</i> .....	174, 175
<i>Ancinini</i> .....	174
<i>Ancinus</i> .....	175
<i>depressus</i> .....	173, 174, 175, 376
<i>Ancinus depressus</i> (Say).—The Isopod Crus- tacean, by Harriet Richardson.....	173
<i>Ancinus granulatus</i> .....	375
<i>Andeton</i> .....	183, 361, 498, 503
<i>Andrena flavoclypeata</i> .....	420
<i>fragariana</i> .....	420
<i>pacifica</i> .....	420
<i>personata</i> .....	420
<i>zizile</i> .....	420
<i>zizileformis</i> .....	420

	Page.		Page.
Anhinga melanogaster.....	465	Astrabe.....	607
Annandale, Nelson. Fresh-water Sponges in the Collection of the United States National Museum. Part I. Specimens from the Philippines and Australia.....	627	Atlantic Coast of the United States.—Description of a New Skate ( <i>Dactylobatus armatus</i> ) from Deep Water off the Southern, by B. A. Bean and A. C. Weed.....	459
Antedon bassett-smithi.....	395	Atlantic Coast of the United States.—Descriptions of two New Species of Electric Rays, of the Family Narcobatidae, from Deep Water off the Southern, by B. A. Bean and A. C. Weed.....	677
Antedonidae.....	408, 648	Australia.—Fresh-water Sponges in the Collection of the U. S. National Museum. Part I. Specimens from the Philippines and, by Nelson Annandale.....	627
Anthophora pacifica.....	414	Authors).—On Brazilian Grasshoppers of the Subfamilies Pyrgomorphinae and Locustinae (Acridinae of, by James A. G. Rehn....	109
Anthrepes cagayanensis.....	444	Bartsch in the Philippine Islands, Borneo, Guam, and Midway Island, with Descriptions of Three New Forms.—A List of Birds collected by Doctor Paul, by E. A. Mearns.....	463
chlorogaster.....	445	Basilan Island thick-head.....	442
griseigularis.....	445	Basketwork. Anyam Gila (Mad Weave): A Malaysian Type of, by Otis T. Mason.....	385
malaccensis.....	445, 473, 475	Bathyscopea typhlops.....	490
wigglesworthi.....	445, 463, 474	Bathyrinus.....	362, 673
Anthus hodgsoni.....	474	Bathymetra.....	366
rufulus.....	474	Bean, Barton A., and Alfred C. Weed.—Description of a New Skate ( <i>Dactylobatus armatus</i> ) from Deep Water off the Southern Atlantic Coast of the United States....	459
Anurida maritima.....	515	— Descriptions of two New Species of Electric Rays, of the Family Narcobatidae, from Deep Water off the Southern Atlantic Coast of the United States.....	677
Anyam Gila (Mad Weave): A Malaysian Type of Basketwork, by Otis T. Mason.....	385	Bees in the U. S. National Museum.—Descriptions of some, by T. D. A. Cockerell..	411
Aonyx cinerea.....	490	Belostomidae.....	561
Aplonis kittlitzi.....	477	Benacus.....	532
Apogonichthyidae.....	599	haldeanum.....	561
Apogonichthys isostigma.....	600	Benthobatis.....	677
nafa.....	599, 600	cervina.....	679
Apophyse humerale.....	571	marcida.....	677, 679
Arctictis binturong.....	490	moresbyi.....	679, 680
Arctogalidia fusca.....	186, 490	Birds collected by Dr. Paul Bartsch in the Philippine Islands, Borneo, Guam, and Midway Island, with Descriptions of Three New Forms.—A List of, by E. A. Mearns..	463
simplex.....	490	Birds, with Descriptions of New and Rare Species.—Additions to the List of Philippine, by E. A. Mearns.....	435
Arenaceous Foraminifera.—Ammodiscoides, a New Genus of, by Joseph A. Cushman....	423	Biunguiculatus.....	4, 16, 17
Arenaria interpres.....	477	Blatella.....	526
Argia apicalis.....	659, 660, 661, 665, 666, 667, 668	germanica.....	555
moesta putrida.....	659, 661, 662, 663, 665, 666, 667, 668	Bolodon.....	612
tibialis.....	660, 661, 665, 666, 667, 668, 669, 670	Boltenia.....	184
violacea.....	659, 668, 669	Bombus.....	528
Argyrosomus artemi.....	166, 167, 168	caeruleus.....	415, 416
erianis.....	165, 168	Boremys pulchra.....	195
Argyrosomus, from the Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of Three New Species of Cisco, or Lake Herring, by David Starr Jordan and B. W. Evermann.....	165	Borneo, Guam, and Midway Island, with Descriptions of Three New Forms.—A List of Birds collected by Dr. Paul Bartsch in the Philippine Islands, by E. A. Mearns.....	463
Argyrosomus hoyi.....	169	Brachypteryx brunneiceps.....	441
huronius.....	166, 167, 168		
nigripinnis.....	170		
tullibee.....	167		
zenithicus.....	169, 170, 171		
Armadillidae.....	432		
Armadilloidea.....	431		
Armatus, from Deep Water off the Southern Atlantic Coast of the United States.—Description of a New Skate ( <i>Dactylobatus</i> , by B. A. Bean and A. C. Weed.....	459		
Arnalia chlorizans.....	135		
gracilis.....	136		
Artamides kochi.....	469		
panayensis.....	469		
Artamus leucorhynchus.....	472		
Articulation of the Wings.—The Thorax of Insects and the, by R. E. Snodgrass.....	511		
Asteria.....	497, 503		
Asterias.....	497, 503		
multiradiata.....	392		
Asterometra.....	365		

	Page.		Page.
<i>Brachypteryx malindangensis</i> .....	441	<i>Camptosaurus nanus</i> .....	198, 227, 234, 236, 237, 267, 269, 273, 280, 287, 294, 298, 299
<i>mindanensis</i> .....	441	<i>prestwichii</i> .....	208, 266, 269, 281, 285, 287, 296, 310
Brain of <i>Triceratops</i> , with Notes on the Braincases of <i>Iguanodon</i> and <i>Magalosau-</i> <i>rus</i> .—On the Skull and the, by O. P. Hay.....	95	<i>valdensis</i> .....	228, 266, 269, 291
Braincase and brain of <i>Triceratops sulcatus</i> ..	104	<i>Camptosaurus</i> , with a Revision of the Species of the Genus, and Descrip- tions of Two New Species.— Osteology of the Jurassic Reptile, by Charles W. Gil- more.....	197
of <i>Iguanodon</i> .....	105	<i>Capillaster</i> .....	495, 496, 501, 503
of <i>Megalosaurus</i> .....	106	Casanowicz, Immanuel M.—The Collection of Rosaries in the United States National Museum.....	333
Braincases of <i>Iguanodon</i> and <i>Megalosaurus</i> .— On the Skull and the Brain of <i>Triceratops</i> , with Notes on the, by O. P. Hay.....	95	<i>Cellithemis eponina</i> .....	656, 667
Brazilian Grasshoppers of the Subfamilies <i>Pyrgomorphinæ</i> and <i>Locustinæ</i> ( <i>Aceridinæ</i> of Authors), by James A. G. Rehn.....	109	<i>Cenometra</i> .....	398
<i>Brevicarpus</i> .....	1, 4, 43	<i>delicata</i> .....	398
<i>Bubulcus coromandus</i> .....	465	<i>unicornis</i> .....	399
Buddhist rosary.....	335	<i>Centropus javanicus</i> .....	468
<i>Buprestis arulenta</i> .....	541, 562	<i>viridis</i> .....	468
<i>gigas</i> .....	541	<i>Cephalacanthidæ</i> .....	604
<i>Butorides javanica</i> .....	465	<i>Cephalophoneus nasutus</i> .....	472
<i>Byrostria fumigata</i> .....	555, 556	<i>Cerastospinus venosus</i> .....	560
<i>Cacatua haematuropygia</i> .....	466	<i>Ceratosaurus nasicornis</i> .....	227
<i>Cænonomada</i> .....	411	<i>Cernatia</i> .....	537, 551
<i>bruneri</i> .....	411	<i>Chacoana melanoxantha</i> .....	413
<i>Cagayan sulu brown-throated sunbird</i> .....	445	<i>Charadrius dominicus fulvus</i> .....	477
<i>Cainocrinus</i> .....	189	<i>Charitometrinæ</i> .....	406, 644
<i>andree</i> .....	182	<i>Cheirothrix parvimanus</i> .....	5
California.—Four New Species of Isopods from the Coast of, by S. J. Holmes and M. E. Gay.....	375	<i>Chelonia</i> .....	210
<i>Calliphora vomitoria</i> .....	568	<i>Chibia cayagensis</i> .....	447
<i>Callisitta mesoleuca</i> .....	473	<i>palawanensis</i> .....	447
<i>Callonotacris</i> .....	128	<i>suluensis</i> .....	463, 474
<i>lophophora</i> .....	129	China Sea.—A New Squirrel from Direction Island, South, by M. W. Lyon, jr.....	509
<i>Callyodon bowersi</i> .....	602	Chinese rosaries.....	338
<i>oedema</i> .....	603	<i>Chirox</i> .....	612
<i>Calometra</i> .....	400	<i>plicatus</i> .....	612, 614
<i>cardium</i> .....	400	<i>Chisel-mouth jack</i> .....	425
<i>multicolor</i> .....	366	<i>Chisternon? interpositum</i> .....	194
<i>Calopteryx æquabilis</i> .....	655, 660	<i>Chisternon? interpositum</i> , the Latter hitherto Unknown.—Description of Two Species of Fossil Turtles, <i>Toxochelys stenopora</i> and, by Oliver P. Hay.....	191
<i>maculata</i> .....	655	<i>Chrysocolaptes lucidus montanus</i> .....	468
<i>Calosoma -Dytiscus</i> .....	531, 532	<i>Cimbex</i> .....	528
<i>scrutator</i> .....	530, 538, 562	<i>americana</i> .....	567
<i>Camptonotus</i> .....	266	Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of Three New Species of, by David Starr Jordan and B. W. Evermann.....	165
<i>amplus</i> .....	276	<i>Cisticola cisticola</i> .....	471
<i>Camptopœum flaviventre</i> .....	416	<i>exilis</i> .....	471
<i>frontale</i> .....	416	<i>Citheronia regalis</i> .....	565
<i>ochraceum</i> .....	416	<i>Clariger</i> .....	607
<i>prinii</i> .....	416	Clark, Austin Hobart. <i>Comatilia</i> , a Remark- able New Genus of Unstalked Crinoids.....	361
<i>submetallicum</i> .....	416	Descriptions of Sev- enteen New Spe- cies of Recent Crinoids.....	633
<i>Camptosaurus</i> .....	96		
<i>amplus</i> .....	266, 268, 275, 276, 277, 278, 298		
<i>browni</i> .....	201, 204, 237, 258, 268, 273, 274, 280, 281, 283, 293, 294, 296, 297, 299		
<i>depressus</i> .....	235, 269, 292, 293, 296		
<i>dispar</i> .....	198, 205, 226, 230, 234, 235, 237, 251, 256, 266, 267, 269, 271, 272, 274, 275, 276, 278, 280, 281, 282, 283, 294, 295, 296, 297, 298, 299		
<i>inkeyi</i> .....	269, 291		
<i>leedsi</i> .....	266, 269, 289, 290		
<i>medius</i> .....	204, 211, 212, 213, 258, 267, 269, 273, 278, 279, 286, 295, 296, 297, 298, 299		

	Page.		Page.
Clark, Austin Hobart. Four New Species of the Crinoid Genus <i>Rhizocrinus</i> .....	673	<i>Comaster multiradiata</i> .....	391, 392
On a Collection of Recent Crinoids from the Philippine Islands.....	391	<i>sentosa</i> .....	391
Revision of the Crinoid Family <i>Comasteridae</i> , with Descriptions of New Genera and Species .....	493	<i>Comasteridae</i> .....	391
Coast of California.—Four New Species of Isopods from the, by S. J. Holmes and M. E. Gay .....	375	with Descriptions of New Genera and Species.—Revision of the Crinoid Family, by A. H. Clark .....	493
Coast of the United States.—Description of a New Skate ( <i>Dactylobatus armatus</i> ) from Deep Water off the Southern Atlantic, by B. A. Bean and A. C. Weed .....	459	<i>Comatella</i> .....	365, 395, 495, 496, 506
Coast of the United States.—Descriptions of Two New Species of Electric Rays, of the Family <i>Narcobatidae</i> , from Deep Water off the Southern Atlantic, by B. A. Bean and A. C. Weed .....	677	<i>nigra</i> .....	395
Cockerell, T. D. A., Descriptions of Some Bees in the U. S. National Museum .....	411	<i>Comatilia</i> .....	365, 495, 496, 497
— and W. W. Robbins.—Notes on Two Slugs of the Genus <i>Veronicella</i> .....	381	<i>Comatilia</i> , a remarkable New Genus of Unstalked Crinoids, by A. H. Clark .....	361
<i>Coelioxys lanceolata</i> .....	415	<i>iridometriformis</i> .....	366, 497
<i>manila</i> .....	415	<i>Comatula</i> .....	183,
<i>Cœlurus fragilis</i> .....	198	394, 494, 495, 496, 497, 498, 503, 506, 507	
Collection of Recent Crinoids from the Philippine Islands.—On a, by Austin H. Clark ..	391	<i>Comatula, fimbriata</i> .....	392
Collection of Rosaries in the United States National Museum, by Immanuel M. Casanowicz .....	333	<i>multiradiata</i> .....	506
Collection of the United States National Museum. Part I. Specimens from the Philippines and Australia.—Fresh-water Sponges in the, by Nelson Annandale .....	627	<i>pectinata</i> .....	394
<i>Collocalia bartschi</i> .....	463, 476	<i>solaris</i> .....	497
<i>fuciphaga</i> .....	476	<i>Comatule</i> .....	497
<i>marginata</i> .....	468	<i>Comatulium</i> .....	3
<i>trogodytes</i> .....	468	<i>Cominia</i> .....	495, 496, 497
<i>unicolor amelis</i> .....	476	<i>Comissia</i> .....	495, 496, 501
<i>Colobometra</i> .....	362, 640	<i>lutkeni</i> .....	501, 502
<i>discolor</i> .....	640	<i>Copsychus mindanensis</i> .....	471
<i>perspinosa</i> .....	640	<i>niger</i> .....	475
<i>Colobometridæ</i> .....	640	<i>Coregonus albus</i> .....	167, 171, 172
<i>Colpolopha</i> .....	121	<i>cismontanus</i> .....	429, 430
<i>obsoleta</i> .....	121	<i>clupeaformis</i> .....	171
<i>Comactinia</i> .....	495, 496, 498	<i>couesi</i> .....	429, 430
<i>Comanthus</i> .....	395, 495, 496, 497, 507	<i>coulteri</i> .....	430
<i>alternans</i> .....	396, 397	<i>labradoricus</i> .....	171
<i>briareus</i> .....	395	<i>lathior</i> .....	172
<i>decameros</i> .....	497	<i>neohantoniensis</i> .....	172
<i>duplex</i> .....	397	<i>oregonius</i> .....	425, 428, 429
<i>intricata</i> .....	507	( <i>Coregonus oregonius</i> ) from McKenzie River, Oregon.—Description of a New Whitefish, by David S. Jordan and J. Otterbein Snyder .....	425
<i>nobilis</i> .....	395	<i>Coregonus otsego</i> .....	172
<i>polynemis</i> .....	396	<i>quadrilateralis</i> .....	168, 428, 430
<i>rotalaria</i> .....	397, 507	<i>sapidissimus</i> .....	171
<i>Comaster</i> .....	365, 391, 495, 496, 498, 501, 503, 506	<i>williamsoni</i> .....	425, 428, 429
<i>coppingeri</i> .....	502	<i>Corone philippina</i> .....	475
<i>lowensis</i> .....	362	<i>Coryacris</i> .....	111
		<i>diversipes</i> .....	111
		<i>Corydalis</i> .....	526
		<i>cornuta</i> .....	539, 542, 564
		Coutière, Henri, The American Species of Snapping Shrimps of the Genus <i>Synalpheus</i> ..	1
		<i>Cranorrhinus leucocephalus</i> .....	467
		Crinoid.—A New American Jurassic, by Frank Springer .....	179
		Crinoid Family <i>Comasteridae</i> , with Descriptions of New Genera and Species.—Revision of the, by A. H. Clark .....	493
		Crinoid Genus <i>Rhizocrinus</i> .—Four New Species of the, by A. H. Clark .....	673
		Crinoids.— <i>Comatilia</i> , a Remarkable New Genus of Unstalked Crinoids, by A. H. Clark .....	361
		Crinoids.—Descriptions of Seventeen New Species of Recent, by A. H. Clark .....	633
		Crinoids from the Philippine Islands.—On a Collection of Recent, by Austin H. Clark ..	391



	Page.		Page.
Crinometra.....	644	Description of a New Skate ( <i>Dactylobatus</i>	
<i>concinna</i> .....	646	<i>armatus</i> ) from Deep Water off the Southern	
<i>gemmata</i> .....	647	Atlantic Coast of the United States, by B. A.	
<i>insculpta</i> .....	646	Bean and A. C. Weed.....	459
<i>margaritacea</i> .....	645	Description of a New Snake from Panama, by	
<i>pulchra</i> .....	644	Leonhard Stejneger.....	457
Crociaspidia.....	411	Description of a New Species of Leatherback	
Crotalometra.....	403, 642	Turtle from the Miocene of Maryland, by	
<i>annandalei</i> .....	642	William Palmer.....	369
<i>eupedata</i> .....	404	Description of a New Whitefish ( <i>Coregonus</i>	
Crustacean <i>Acanthoniscus</i> Spiniger Kinahan		<i>oregonius</i> ) from McKenzie River, Oregon,	
redescribed.—The Isopod, by Harriet		by David S. Jordan and J. Otterbein Sny-	
Richardson.....	431	der.....	425
Crustacean, <i>Ancinus depressus</i> (Say).—The		Description of Two Species of Fossil Turtles,	
Isopod, by Harriet Richardson.....	173	<i>Toxochelys stenopora</i> and <i>Chisternon?</i> in-	
Cryptolopha malindangensis.....	440	terpositum, the Latter hitherto Unknown,	
<i>mindanensis</i> .....	440, 441, 443	by Oliver P. Hay.....	191
Cumnora ( <i>Camptosaurus</i> ) <i>dispar</i> .....	270	Descriptions of New and Rare Species.—Ad-	
Cumnoria ( <i>Iguanodon</i> ) <i>prestwichii</i> .....	289	ditions to the List of Philippine Birds, with,	
<i>prestwichii</i> .....	285	by E. A. Mearns.....	435
Cyaneoderes.....	416	Descriptions of New Genera and Species of	
<i>fairchildi</i> .....	415	Fishes from Japan and the Riu Kiu Is-	
Cyllene robinæ.....	531, 538, 562	lands, by J. O. Snyder.....	597
Cyllometra.....	362, 399, 647	Descriptions of New Genera and Species.—	
<i>manca</i> .....	399	Revision of the Crinoid Family <i>Comaster-</i>	
<i>studer</i> .....	642	idæ, with, by A. H. Clark.....	493
<i>tapobanes</i> .....	641	Descriptions of New Species and a Revised	
Cynopterus montanoi.....	487, 490	List.—Additional Notes on Mammals of the	
Cyornis philippinensis.....	469	Rho-Linga Archipelago, with, by M. W.	
Cyrtostomus jugularis <i>aurora</i> .....	444	Lyon, jr.....	479
<i>dinagatensis</i> .....	444	Descriptions of New Species.—Notes on the	
<i>jugularis</i> .....	443, 444, 473	Fossil Mammalian Genus <i>Ptilodus</i> , with,	
<i>woodi</i> .....	444, 473	by J. W. Gidley.....	611
Dactylobatus.....	459	Descriptions of Seventeen New Species of Re-	
<i>armatus</i> .....	459	cent Crinoids, by A. H. Clark.....	633
( <i>Dactylobatus armatus</i> ) from Deep Water off		Descriptions of some Bees in the U. S. Na-	
the Southern Atlantic Coast of the United		tional Museum, by T. D. A. Cockerell.....	411
States.—Description of a New Skate, by		Descriptions of Three New Forms.—A List of	
B. A. Bean and A. C. Weed.....	459	Birds collected by Dr. Paul Bartsch in the	
Dactyloptena gilberti.....	604, 605	Philippine Islands, Borneo, Guam, and Mid-	
<i>orientalis</i> .....	604	way Island, with, by E. A. Mearns.....	463
Dasylophus superciliosus.....	468	Descriptions of Three New Species of Cisco, or	
Decacnimos.....	183	Lake Herring ( <i>Argyrosomus</i> ), from the	
Decametrocrinus.....	363	Great Lakes of America; with a Note on the	
Deep Water off the Southern Atlantic Coast of		Species of Whitefish, by David S. Jordan	
the United States.—Description of a New		and B. W. Evermann.....	165
Skate ( <i>Dactylobatus armatus</i> ) from, by B.		Descriptions of Two New Species of Electric	
A. Bean and A. C. Weed.....	459	Rays, of the Family <i>Narcobatidæ</i> , from	
Deep Water off the Southern Atlantic Coast of		Deep Water off the Southern Atlantic	
the United States.—Descriptions of Two		Coast of the United States, by B. A. Bean	
New Species of Electric Rays, of the Family		and A. C. Weed.....	677
<i>Narcobatidæ</i> , from, by B. A. Bean and A.		Descriptions of Two New Species.—Osteology	
C. Weed.....	677	of the Jurassic Reptile <i>Camptosaurus</i> , with	
Demiegretta sacra.....	465	a Revision of the Species of the Genus, and,	
Democrinus parvifiti.....	673, 676	by Charles W. Gilmore.....	197
Dendroctonus.....	563	<i>Dicæum papuense</i> .....	473
<i>valens</i> .....	524, 538	<i>pygmæum</i> .....	473
Dendrocygna arcuata.....	465	<i>Dichroplus</i> .....	159
Depressus (Say).—The Isopod Crustacean,		<i>brasiliensis</i> .....	159
<i>Ancinus</i> , by Harriet Richardson.....	173	<i>punctulatus</i> .....	159
Dermatochelys.....	370, 371	<i>Dicrurus baliassius</i> .....	447, 474
<i>coriacea</i> .....	370, 371, 372	<i>mindorensis</i> .....	447
Description of a New Isopod of the Genus		<i>Didymops transversa</i> .....	659
<i>Jæropsis</i> from Patagonia, by Harriet Rich-		<i>Dinagat orange-breasted sunbird</i> .....	444
ardson.....	421	<i>Diracodon laticeps</i> .....	198

	Page.		Page.
Direction Island, South China Sea.—A New		Expedio.....	606, 607
Squirrel from, by M. W. Lyon, jr.....	509	parvulus.....	606
Dissosteira.....	534	Extracrinus.....	179
carolina.....	539, 555	Family Comasteridæ, with Descriptions of	
Dorocordulia libera.....	661	New Genera and Species.—Revision of the	
Draconata.....	121	Crinoid, by A. H. Clark.....	193
Dragonflies of the Mississippi Valley collected		Family Narcobatidæ, from Deep Water off	
during the Pearl Mussel Investigations on		the Southern Atlantic Coast of the United	
the Mississippi River, July and August, 1907,		States.—Descriptions of Two New Species	
by Charles Branch Wilson.....	653	of Electric Rays of the, by B. A. Bean and	
Dryosaurus altus.....	198, 236, 299	A. C. Weed.....	677
Dytiscus dauricus.....	530, 538, 562	Felis tigris.....	490
Edoliosoma everetti.....	463, 469	Ficus religiosa.....	336
Elæocarpus ganitrus.....	333	Fishes from Japan and the Riu Kiu Islands.—	
Elæochlora.....	124	Descriptions of New Genera and Species of,	
humilis.....	124, 126	by J. O. Snyder.....	597
pulchella.....	126	Foraminifera.—Ammodiscoides, a New Genus	
trilineata.....	124	of Arenaceous, by Joseph A. Cushman.....	423
viridicata.....	124, 126	Forms.—A List of Birds collected by Dr. Paul	
Elanus hypoleucus.....	465	Bartsch in the Philippine Islands, Borneo,	
Electric Rays, of the Family Narcobatidæ,		Guam, and Midway Island, with Descriptions	
from Deep Water off the Southern Atlantic		of Three New, by E. A. Mearns.....	463
Coast of the United States.—Descriptions		Fossil Mammalian Genus Ptilodus, with Descriptions	
of Two New Species of, by B. A. Bean and		of New Species.—Notes on the, by	
A. C. Weed.....	677	J. W. Gidley.....	611
Emballonura monticola.....	488	Fossil Turtles, Toxochelys stenopora and	
peninsularis.....	488, 491	Chistemon? interpositum, the latter hitherto	
Emphoropsis.....	414	Unknown.—Description of Two Species of,	
murihirta.....	414	by Oliver P. Hay.....	191
murina.....	414	Four New Species of the Crinoid Genus Rhizo-	
pascoensis.....	414	crinus, by A. H. Clark.....	673
vierecki.....	414	Four New Species of Isopods from the Coast	
Enallagma antennatum.....	657, 666	of California, by S. J. Holmes and M. E.	
carunculatum.....	657	Gay.....	375
ebrium.....	657, 658, 660, 661, 662, 663, 664	Fresh-water Sponges in the Collection of the	
hageni.....	655,	United States National Museum. Part I.	
657, 658, 660, 661, 662, 663, 664, 670		Specimens from the Philippines and Aus-	
piscinarium.....	668	tralia, by Nelson Annandale.....	627
signatum.....	657	Galeopterus chombolis.....	486, 487, 490
Enerini minoris pulcre ramificatum.....	183	tallonis.....	487
Enerinus asteria.....	184, 185	temminckii.....	490
boltenii.....	184	tuancus.....	486, 487
caput-medusæ.....	184	Gallus gallus.....	603
coralloides.....	183, 185	Gay, M. E., and S. J. Holmes.—Four New Species	
liliiformis.....	184, 185	of Isopods from the Coast of California.....	375
lilium marinum.....	182	Genera and Species of Fishes from Japan and	
mylii.....	184	the Riu Kiu Islands.—Descriptions of New,	
Endoxocrinus.....	409	by J. O. Snyder.....	597
alternicirrus.....	391, 409	Genera and Species.—Revision of the Crinoid	
Enellagma durum.....	553	Family Comasteridæ, with Descriptions of	
Entrochites fungitæ adhærens.....	183	New, by A. H. Clark.....	493
marosus.....	183	Genus Gymnura.—Remarks on the Insecti-	
ramosus.....	182	vores of the, by M. W. Lyon.....	449
Ephydatia fortis.....	631	Genus Jæropsis from Patagonia.—Description	
Epicharoides.....	413	of a New Isopod of the, by Harriet	
Epicordulia princeps.....	660, 663, 664, 665	Richardson.....	421
Erythemis simplicicollis.....	656,	Genus Arenaceous Foraminifera.—Ammodiscoides,	
661, 665, 666, 667, 668, 669, 670		A New, by Joseph A. Cushman.....	423
Eudiocrinus.....	633	Genus of Unstalked Crinoids.—Comatilla, A	
ornatus.....	633	Remarkable New, by A. H. Clark.....	361
Eudynamis mindanensis.....	468	Genus Ptilodus, with Descriptions of New	
Eurystomus orientalis.....	466	Species.—Notes on the Fossil Mammalian,	
Euspongilla.....	627	by J. W. Gidley.....	611
Evermann, Barton Warren, and David Starr		Genus Rhizocrinus.—Four New Species of the	
Jordan. Descriptions of Three New Species		Crinoid, by A. H. Clark.....	673
of Cisco, or Lake Herring (Argyrosomus),		Genus Synalpheus.—The American Species	
from the Great Lakes of America; with a		of Snapping Shrimps of the, by Henri Cou-	
Note on the Species of Whitefish.....	165	tière.....	1

	Page.		Page.
Genus <i>Veronicella</i> .—Notes on Two Slugs of the, by W. W. Robbins and T. D. A. Cockrell.....	381	<i>Halcyon cinnamominus</i> .....	476
<i>Gerygone rhizophoræ</i> .....	469	<i>gularis</i> .....	467
<i>simplex</i> .....	469	<i>winchelli</i> .....	467
Gidley, James Williams.—Notes on the Fossil Mammalian Genus <i>Ptilodus</i> , with Descriptions of New Species.....	611	<i>Halictus manilæ</i> .....	420
Gila (Mad Weave): A Malaysian Type of Basketwork.—Anyam, by Otis T. Mason..	385	<i>pectoralis</i> .....	419
Gilmore, Charles W.—Osteology of the Jurassic Reptile <i>Camptosaurus</i> , with a Revision of the Species of the Genus, and Descriptions of Two New Species.....	197	<i>philippinensis</i> .....	419
<i>Glottis nebularius</i> .....	464	<i>Halodon formosus</i> .....	623
<i>Glyptodon</i> .....	370	<i>serratus</i> .....	623
<i>Glyptometra</i> .....	407	<i>Haplocanthosaurus</i> .....	241
<i>tuberosa</i> .....	407	<i>Hathrometra</i> .....	362, 366
<i>Gobiidæ</i> .....	635	Hay, Oliver P. Description of Two Species of Fossil Turtles, <i>Toxochelys stenopora</i> and <i>Chisternon?</i> <i>interpositum</i> , the Latter hitherto Unknown.....	191
<i>Gobius semidoliatus</i> .....	606	On the Skull and the Brain of <i>Triceratops</i> , with Notes on the Brains of <i>Iguanodon</i> and <i>Megalosaurus</i> ..	95
<i>Goldfussia</i> .....	507	<i>Helimetra</i> .....	363
<i>Gomphus amnicola</i> .....	661, 665, 667	<i>Helionotus</i> .....	121
<i>brevis</i> .....	558	<i>mirabilis</i> .....	121
<i>crassus</i> .....	661	<i>Hemiprocne comata</i> .....	467
<i>descriptus</i> .....	666	<i>comata</i> .....	467
<i>externus</i> .....	659, 661, 663, 664, 665, 667	<i>major</i> .....	467
<i>fraternus</i> .....	658, 659, 661, 662, 663	Herring ( <i>Argyrosomus</i> ), from the Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of Three New Species of Cisco, or Lake, by David Starr Jordan and B. W. Evermann..	165
<i>notatus</i> .....	669	<i>Hesperapis</i> .....	417
<i>plagiatus</i> .....	553, 667	<i>Hæterina americana</i> .....	660, 664, 666, 669
<i>spicatus</i> .....	655, 656	<i>Heterometra</i> .....	636
<i>vastus</i> .....	659, 661, 663, 665, 669	<i>compta</i> .....	636
<i>Goniophilis</i> .....	299	<i>singularis</i> .....	638
<i>Gordiaminna</i> .....	423	<i>Hexagenia bilineata</i> .....	535, 553
Grasshoppers of the Subfamilies <i>Pyrgomorphinæ</i> and <i>Locustinæ</i> ( <i>Acridinæ</i> of Authors).—On Brazilian, by James A. G. Rehn.....	109	<i>Himerometridæ</i> .....	397, 635
Great billed Parrot.....	435	<i>Hindu or Brahman Rosary</i> .....	334
Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of Three New Species of Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the, by David Starr Jordan and B. W. Evermann.....	165	<i>Hippiscus phœnicopterus</i> .....	535, 539, 555
<i>Greeleyella</i> .....	417	<i>Hirundo gutturalis</i> .....	468
<i>Gryllotalpa borealis</i> .....	555	<i>javanica</i> .....	468, 475
<i>Gryllus</i> .....	526	Holmes, S. J., and M. E. Gay. Four New Species of Isopods from the Coast of California.....	375
<i>domesticus</i> .....	545, 559	<i>Holorusia</i> .....	529
<i>grandis</i> .....	134	<i>grandis</i> .....	527, 568
( <i>Locusta</i> ) <i>eristatus</i> .....	134	<i>Homalosaparus</i> .....	154
<i>dux</i> .....	134	<i>canonicus</i> .....	154, 155
<i>pallens</i> .....	158	<i>sordidatus</i> .....	155
<i>pennsylvanicus</i> .....	539, 555, 557, 559	<i>Hoplitosaurus (Stegosaurus) marshi</i> .....	300
<i>vitreipennis</i> .....	135	<i>Hoplonomia quadrifasciata</i> .....	419
Guam, and Midway Island, with Descriptions of Three New Forms.—A List of Birds collected by Dr. Paul Bartsch in the Philippine Islands, Borneo, by E. A. Mearns....	463	<i>Hydrochelidon hybrida</i> .....	464
Guam Island swiftlet.....	476	<i>Hydrophilus</i> .....	536
<i>Gymnura</i> .....	449, 450	<i>triangularis</i> .....	531, 538, 562
<i>alba</i> .....	450, 452, 453, 454	<i>Hylomys</i> .....	449, 450
<i>gymnura</i> .....	451, 453, 454	<i>Hyloterpe albiventris</i> .....	472
<i>gymnura</i> .....	451, 452	<i>apoensis</i> .....	442
<i>minor</i> .....	453	<i>basilaneica</i> .....	442
<i>rafflesii</i> .....	451	<i>Hypalocerinus</i> .....	409, 650
<i>Gymnura</i> .—Remarks on the Insectivores of the Genus, by M. W. Lyon.....	449	<i>naresianus</i> .....	391, 409, 651
<i>Halcyon chloris</i> .....	467	<i>ornatus</i> .....	651
		<i>springeri</i> .....	650
		<i>Hypalometra</i> .....	362
		<i>Hypomacrotera</i> .....	417
		<i>Hypothyrmis azurea</i> .....	469
		<i>Hypsilothon</i> .....	218, 246
		<i>foxi</i> .....	211, 246, 258, 261, 265



	Page.		Page.
<i>Ichthyocampus nox</i> .....	598	<i>Jæropsis</i> from Patagonia.—Description of a	
<i>Ichthyosauria</i> .....	210	New Isopod of the Genus, by	
<i>Iguanodon</i> .....	1, 103	Harriet Richardson.....	421
<i>Iguanodon</i> and <i>Megalosaurus</i> .—On the Skull		<i>lobata</i> .....	421
and the Brain of <i>Triceratops</i> ,		<i>marionis</i> .....	421
with Notes on the Braincases of,		<i>neo-zealandica</i> .....	421
by O. P. Hay.....	95	<i>patagoniensis</i> .....	421
<i>bernissartensis</i> .....	213, 216, 220, 221, 246	<i>rathbunæ</i> .....	421
<i>dawsoni</i> .....	272	<i>Japamala</i> .....	334
<i>mantelli</i> .....	211, 288	<i>Japan</i> and the <i>Riu Kiu</i> Islands.—Descriptions	
<i>prestwichii</i> .....	285, 290	of New Genera and Species of Fishes from,	
<i>Ilyocrinus recuperatus</i> .....	673, 676	by J. O. Snyder.....	597
<i>Ilyodromus gibba</i> var. <i>repens</i> .....	412	<i>Japanese rosaries</i> .....	341
<i>Insectivores</i> of the Genus <i>Gymnura</i> .—Re-		<i>Japyx</i> .....	519, 520, 552
marks on the, by M. W. Lyon.....	449	<i>Jodacris</i> .....	146
<i>Insects</i> and the Articulation of the Wings.—		<i>ferruginea</i> .....	146, 147
The Thorax of, by R. E. Snodgrass.....	511	<i>fulcillata</i> .....	147
<i>Interpositum</i> , the Latter hitherto Un-		<i>Jordan</i> , David Starr and Barton Warren	
known.—Description of Two Species of Fos-		Evermann.—Descriptions of Three New	
sil Turtles, <i>Toxochelys stenopora</i> and		Species of Cisco, or Lake Herring ( <i>Argyro-</i>	
<i>Chisternon</i> ?, by Oliver P. Hay.....	191	<i>somus</i> ), from the Great Lakes of America;	
<i>Inu</i> .....	607	with a Note on the Species of Whitefish....	165
<i>ama</i> .....	608	— and John Otterbein Snyder.—Description	
<i>koma</i> .....	607	of a New Whitefish ( <i>Coregonus oregonius</i> )	
<i>Inusia</i> .....	139	from McKenzie River, Oregon.....	425
<i>bonitensis</i> .....	139	<i>Jumbo herring</i> or <i>Erie cisco</i> .....	165
<i>pallida</i> .....	139	<i>Jurassic Crinoid</i> .—A New American, by	
<i>Investigations</i> on the Mississippi River, July		Frank Springer.....	179
and August, 1907.—Dragonflies of the Mis-		<i>Jurassic Reptile Camptosaurus</i> , with a Revi-	
sissippi Valley collected during the Pearl		sion of the Species of the Genus, and De-	
Mussel, by Charles Branch Wilson.....	653	scriptions of Two New Species.—Osteology	
<i>Iole cinericeps</i> .....	470	of the, by C. W. Gilmore.....	197
<i>everetti</i> .....	470	<i>Kinahan</i> redescribed.—The Isopod Crusta-	
<i>guimarasensis</i> .....	470	cean <i>Acanthoniscus spiniger</i> , by Harriet	
<i>gularis</i> .....	470	Richardson.....	431
<i>Iridometra</i> .....	362, 365, 408	<i>Koptorthosoma cæruleum</i> .....	415
<i>exquisita</i> .....	408	<i>Lævimanus</i> .....	1, 4, 16, 17, 53, 55
<i>nana</i> .....	362	<i>Lake Herring</i> ( <i>Argyrosomus</i> ), from the Great	
<i>Ischnoptera hyalina</i> .....	539, 555, 556	Lakes of America; with a Note on the	
<i>Ischnura posita</i> .....	658, 662	Species of Whitefish.—Descriptions of	
<i>verticalis</i> .....	655, 657, 663, 664, 666, 668	Three New Species of Cisco, or, by David	
<i>Isis asteria</i> .....	184	Starr Jordan and B. W. Evermann.....	165
<i>Isocrinus alternicirrus</i> .....	188	<i>Lake Huron cisco</i> .....	167
<i>asteria</i> .....	184, 188, 189	<i>Lakes of America</i> ; with a Note on the Species	
<i>decorus</i> .....	187, 188, 189, 410, 650, 651	of Whitefish.—Descriptions of Three New	
<i>knighti</i> .....	180	Species of Cisco, or Lake Herring ( <i>Argy-</i>	
<i>leuthardi</i> .....	187	<i>rosomus</i> ), from the Great, by David Starr	
<i>naresianus</i> .....	190	Jordan and B. W. Evermann.....	165
<i>parre</i> .....	188, 189	<i>Lalage niger</i> .....	470
<i>wyville-thomsoni</i> .....	188, 189	<i>Lamprocorax panayensis</i> .....	475
<i>Isopod Crustacean Acanthoniscus spiniger</i>		<i>Laosaurus</i> .....	216, 260, 261
<i>Kinahan</i> redescribed, by Harriet Richardson	431	<i>consors</i> .....	236
<i>Isopod Crustacean, Ancinus depressus</i> (Say),		<i>Laraleuas minor</i> .....	144
by Harriet Richardson.....	173	<i>Leatherback Turtle</i> from the Miocene of	
<i>Isopod</i> of the Genus <i>Jæropsis</i> from Pata-		Maryland.—Description of a New Species	
gonia.—Description of a New, by Harriet		of, by William Palmer.....	369
Richardson.....	421	<i>Leiotettix</i> .....	159
<i>Isopods</i> from the Coast of California.—Four		<i>viridis</i> .....	159
New Species of, by S. J. Holmes and M. E.		<i>Lepisma</i> .....	552
Gay.....	375	<i>Leptocoma sperata</i> .....	473
<i>Ixobrychus cinnamomea</i> .....	465	<i>Leptognathus argus</i> .....	458
<i>Jæropsis brevicornis</i> .....	421	<i>Leptomerinthoprora</i> .....	149
<i>curvicornis</i> .....	421	<i>æqualis</i> .....	150
<i>dollfusi</i> .....	421	<i>brevipennis</i> .....	149, 150



	Page.		Page.
Leptonemaster.....	495, 496, 498	Mariametra subearinata.....	647
venustus.....	498, 499	Marsupialia.....	623
Leptysma.....	134	Maryland.—Description of a New Species of	
obscura.....	134	Leatherback Turtle from the Miocene of, by	
Leptysmia.....	135	William Palmer.....	369
pallida.....	135	Mason, Otis T. Anyam Gila (Mad Weave):	
rosea.....	135	A Malaysian Type of Basketwork.....	385
Lestes inequalis.....	655, 657, 661	Mastigometra.....	649
rectangularis.....	659, 663, 664	flagellifera.....	649
uncatus.....	553, 655	micropoda.....	649
vigilax.....	657, 664, 666	Mastusia.....	142
Leucorhinia intacta.....	655, 656, 658, 660, 661	koebelei.....	142
proxima.....	657, 658	quadricarinata.....	142
Libellula auripennis.....	553	spectabilis.....	142
exusta.....	655, 657, 670	McKenzie River, Oregon.—Description of a	
luctuosa.....	658, 660, 665	New Whitefish ( <i>Coregonus oregonus</i> ) from,	
Libellula pulchella.....	553, 654, 655, 656, 657,	By David S. Jordan and J. Otterbein	
658, 659, 660, 661, 664, 665, 667, 668, 669, 671		Snyder.....	425
quadrimaculata.....	656,	Mearns, Edgar Alexander. Additions to the	
657, 658, 659, 660, 661, 666, 670		List of Philip-	
List of Philippine Birds, with Descriptions of		pine Birds, with	
New and Rare Species.—Additions to the,		Descriptions of	
by E. A. Mearns.....	435	New and Rare	
Lithobius.....	537, 541, 551	Species.....	435
Lobipes lobatus.....	435	A List of Birds	
Locustinae (Acridinae).....	110	collected by Dr.	
Locustinae (Acridinae of Authors).—On Bra-		Paul Bartsch in	
zilian Grasshoppers of the Subfamilies Pyr-		the Philippine	
gomorphinae and, by James A. G. Rehn.....	109	Islands, Borneo,	
Longjaw of Lake Superior.....	169	Guam, and Mid-	
Loriculus bonapartei.....	463, 466	way Island,	
Luciogobius.....	606, 607	with Descrip-	
Lutra cinerea.....	485	tions of Three	
Lyon, Marcus Ward, jr. Additional Notes		New Forms.....	463
on Mammals of		Mecistocephalus.....	537, 541
the Rhio-Linga		Megachile robbii.....	415
Archipelago, with		Megalosaurus.....	106, 227
Descriptions of		Megalosaurus.—On the Skull and the Brain of	
New Species and		Triceratops, with Notes on the Braincases	
a Revised List..	479	of Iguanodon and, by O. P. Hay.....	95
A New Squirrel		Megalurus palustris.....	472
from Direction		Megapodius cumingi.....	463
Island, South		Melanoplus femur-rubrum.....	555
China Sea.....	509	Meliturgopsis.....	414
Remarks on the In-		Melolontha vulgaris.....	524, 531, 538, 545, 562
sectivores of the		Merops americanus.....	467
Genus <i>Gymnura</i> .....	449	philippinus.....	467
Macaca fascicularis.....	488, 491	Mesopeltis dimidiatus.....	458
nemestrina.....	491	longifrenis.....	457
Macharopoles.....	152	sanniolus.....	458
rostratus.....	152	Mesotrichia.....	415
Machilis.....	516	abbotti.....	415, 416
Macrochelys scaldii.....	372	caerulea.....	415
Macromia teniolata.....	668, 669	Metacrinus.....	410
Macropygia tenuirostris.....	464	acutus.....	187
(Mad Weave): A Malaysian Type of Basket-		wyvillii.....	391, 410
work.—Anyam Gila, by Otis T. Mason.....	385	Micrandrena.....	411, 420
Malaysian Type of Basketwork.—Anyam		pacific.....	420
Gila (Mad Weave) A, by Otis T. Mason.....	385	Microcentrum laurifolium.....	533, 555, 559
Mammalian Genus <i>Ptilodus</i> , with Descrip-		Microphis ocellatus.....	598
tions of New Species.—Notes on the Fossil,		Midway Island, with Descriptions of Three	
by J. W. Gidley.....	611	New Forms.—A List of Birds collected by	
Mammals of the Rhio-Linga Archipelago,		Dr. Paul Bartsch in the Philippine Islands,	
with Descriptions of New Species and a Re-		Borneo, Guam, and, by E. A. Mearns.....	463
vised List.—Additional Notes on, by M. W.		Millericrinus.....	183
Lyon, jr.....	479	echinatus.....	184, 185
Manis javanica.....	479, 489	Mindanao rufous-tailed flycatcher.....	439

	Page.		Page.
Mindanao yellow-breasted sunbird.....	443	New and Rare Species.—Additions to the List of Philippine Birds, with Descriptions of, by E. A. Mearns.....	435
Mindoro drongo shrike.....	447	New Forms.—A List of Birds collected by Dr. Paul Bartsch in the Philippine Islands, Borneo, Guam, and Midway Island, with Descriptions of Three, by E. A. Mearns....	463
Miocene of Maryland.—Description of a New Species of Leatherback Turtle from the, by William Palmer.....	369	New Genera and Species of Fishes from Japan and the Riu Kiu Islands.—Descriptions of, by J. O. Snyder.....	597
Mississippi Valley collected during the Pearl Mussel Investigations on the Mississippi River, July and August, 1907.—Dragonflies of the, by C. B. Wilson.....	653	New Genera and Species.—Revision of the Crinoid Family Comasteridae, with Descriptions of, by A. H. Clark.....	493
Mohammedan rosary.....	348	New Genus of Arenaceous Foraminifera.—Ammodiscoides, A, by Joseph A. Cushman.....	423
Morosaurus agilis.....	207, 227	New Genus of Unstalked Crinoids.—Comatilia, A Remarkable, by A. H. Clark.....	361
lentus.....	198	New Isopod of the Genus Jæropis from Patagonia.—Description of a, by Harriet Richardson.....	421
Motacilla boarula melanope.....	474	New Skate (Dactylobatus armatus) from Deep Water off the Southern Atlantic Coast of the United States.—Description of a, by B. A. Bean and A. C. Weed.....	459
ocularis.....	474	New Snake from Panama.—Description of a, by Leonhard Stejneger.....	457
Mount Malindang flycatcher-warbler.....	440	New Species and a Revised List.—Additional Notes on Mammals of the Rhio-Linga Archipelago, with Descriptions of, by M. W. Lyon, jr.....	479
racquet-tailed parrot.....	437	New Species.—Notes on the Fossil Mammalian Genus Ptilodus, with Descriptions of, by J. W. Gidley.....	611
shortwing.....	441	New Species of Cisco, or Lake Herring (Argyrosomus), from the Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of Three, by David Starr Jordan and B. W. Evermann.....	165
silver-eye.....	443	New Species of Electric Rays, of the Family Narcobatidae, from Deep Water off the Southern Atlantic Coast of the United States.—Descriptions of Two, by B. A. Bean and A. C. Weed.....	677
wood-accentor.....	441	New Species of Isopods from the Coast of California.—Four, by S. J. Holmes and M. E. Gay.....	375
Multituberculata.....	623	New Species of Leatherback Turtle from the Miocene of Maryland.—Description of a, by William Palmer.....	369
Munia cabanisi.....	474	New Species of Recent Crinoids.—Descriptions of Seventeen, by A. H. Clark.....	423
jagori.....	474	New Species of the Crinoid Genus Rhizocrinus.—Four, by A. H. Clark.....	673
oryzivora.....	474	New Species.—Osteology of the Jurassic Reptile Camptosaurus, with a Revision of the Species of the Genus, and Descriptions of Two, by Charles W. Gilmore.....	197
Mus asper.....	483, 490	New Squirrel from Direction Island, South China Sea, by M. W. Lyon, jr.....	509
batamanus.....	490	New Whitefish (Coregonus oregonius) from McKenzie River, Oregon.—Description of a, by David S. Jordan and J. Otterbein Snyder.....	425
chombolis.....	490	Nonia amabilis.....	419
concolor.....	490	chandleri.....	419
firmus.....	484, 485, 490	(Creicaspidia) chandleri.....	418
fremens.....	490		
jerdoni.....	483		
lingensis.....	484, 490		
rattus.....	490		
Muscadivores ænea.....	464		
nuchalis.....	464		
palmasensis.....	436		
pickeringi.....	436		
Muscicapula westermanni.....	46		
Museum.—The Collection of Rosaries in the United States National, by Immanuel M. Casanowicz.....	333		
Mussel Investigations on the Mississippi River, July and August, 1907.—Dragonflies of the Mississippi Valley collected during the Pearl, by C. B. Wilson.....	653		
Myotis muricola.....	488, 491		
Myristicivora bicolor.....	464		
Myzomela rubratra.....	477		
Næsa depressa.....	173, 175		
Nannosciurus pulcher.....	490		
Narcobatidae, from Deep Water off the Southern Atlantic Coast of the United States.—Descriptions of two New Species of Electric Rays, of the Family, by B. A. Bean and A. C. Weed.....	677		
National Museum. Part I. Specimens from the Philippines and Australia.—Fresh-water Sponges in the Collection of the United States, by Nelson Annandale.....	627		
Nehalennia irene.....	658		
Nemaster.....	495, 496, 503		
grandis.....	503, 504		
Neomeris.....	4, 6, 33		
Neuronina ocellifera.....	539, 542, 565		
New American Jurassic Crinoid, by Frank Springer.....	179		

	Page.		Page.
Nomia (Hoplonomia) quadrifasciata.....	419	Oxybleptella.....	136
maculata.....	419	pulchella.....	136
nigripes.....	419	sagitta.....	136
scutellaris.....	419	Pachydiplax longipennis.....	534,
Nordmann's Tern.....	435	553, 665, 666, 667, 668, 669	
Northern Phalarope.....	435	Pachylometra.....	406
Note on the Species of Whitefish.—Descrip- tions of Three New Species of Cisco, or Lake Herring (Argyrosomus), from the Great Lakes of America; with a, by David Starr Jordan and B. W. Evermann.....	165	angustialyx.....	407
Notes on Mammals of the Rhio-Linga Archi- pelago, with Descriptions of New Species and a Revised List.—Additional, by M. W. Lyons, jr.....	479	levigata.....	406
Notes on the Braincases of Iguanodon and Megalosaurus.—On the Skull and the Brain of Triceratops, with, by O. P. Hay.....	95	Padangia.....	375
Notes on the Fossil Mammalian Genus Ptilo- dus, with Descriptions of New Species, by J. W. Gidley.....	611	Palmas Island fruit-eating pigeon.....	436
Notes on Two Slugs of the Genus Veronicella, by W. W. Robbins and T. D. A. Cockerell.....	381	Palmer, William. Description of a New Spec- ies of Leatherback Turtle from the Miocene of Maryland.....	369
Nucceria.....	149	Palmier marin.....	184
Numenius tahitiensis.....	478	Panama.—Description of a New Snake from, by Leonhard Stejneger.....	457
variegatus.....	464	Pandanus fascicularis.....	385
Nycticorax manillensis.....	465	Paracornops.....	141
Oceanodroma leucorhoa.....	477	aquaticum.....	141
tristrami.....	477	Paradichroplus.....	158
Ochthodromus geoffroyi.....	464	bipunctatus.....	158
Ocimum sanctum.....	334	fusiformis.....	158
Oligometra.....	399	Paradoxurus brunneipes.....	490
pulchella.....	399	hermaphroditus.....	490
Omalolettix.....	149	Parafriesea brasiliensis.....	416
nebulosa.....	149	prinii.....	416
signatipes.....	149	Paraleuas.....	144
Ommexecha cyanopteron.....	110	frater.....	144
Omura.....	110	Parametra.....	406
congrua.....	110	compressa.....	406
Oniscoidea.....	431	Parandrena.....	417
Oniscus spiniger.....	431	Parascopas.....	159
Opandrena.....	420	chapidensis.....	159
Opsomala cylindroides.....	136	obesus.....	159
puncticeps.....	141	Parasiobla.....	527, 528
Oregon.—Description of a New Whitefish (Coregonus oregonius) from McKenzie River, by David S. Jordan and J. Otterbein Snyder.....	425	Pardaliparus elegans.....	472
Oregonius from McKenzie River, Oregon.— Description of a New Whitefish (Coregonus; by David S. Jordan and J. Otterbein Snyder.....	425	Patagonia.—Description of a New Isopod of the Genus Jæropsis from, by Harriet Rich- ardson.....	421
Oriolus chinensis.....	474	Paulsoni.....	4, 21
Ornithorhynchus.....	623	Pearl Mussel Investigations on the Mississippi River, July and August, 1907.—Dragonflies of the Mississippi Valley collected during the, by C. B. Wilson.....	653
Orthorhamphus magnirostris.....	465	Penelopides affinis.....	467
Orthotomus frontalis.....	471	panini.....	467
ruficeps.....	471	Pentacrinites asteriscus.....	179, 180
Osmilia.....	162	Pentacrinittidæ.....	409, 650
flavo-lineata.....	162	Pentacrinus asteriscus.....	188
violacea.....	162	beaugrandi.....	189
Osmotreron vernans.....	464	(Cainocrinus) andrææ.....	189
Osteology of the Jurassic Reptile Campto- saurus, with a Revision of the Species of the Genus, and Descriptions of Two New Spe- cies, by C. W. Gilmore.....	197	caput-medusæ.....	184
Otomela lucionensis.....	472	fossilis.....	182
Otus steerei.....	437	subangularis.....	182
		whitei.....	188, 189
		Pentametrocrinus.....	363
		Perdidomorpha bruneri.....	417
		Perditomorpha.....	411, 416, 417
		Pericrocotus marchese.....	463, 469
		Perithemis domitia.....	663, 664, 665, 666, 670
		Perometra.....	362
		Petrophila manillensis.....	471
		Pezotettix.....	158
		Phalacrocorca.....	516
		Phanogenia.....	365, 392, 493, 506, 507
		carpenteri.....	392
		delicata.....	393

	Page.		Page.
<i>Phanogenia minima</i> .....	392	<i>Psephophorus polygonus</i> .....	370, 371, 372
<i>multibrachiata</i> .....	392	<i>pseudostracion</i> .....	372
<i>Phapitreron albifrons</i> .....	436	<i>scaldii</i> .....	372
<i>brevirostris</i> .....	436, 464	<i>(Macrochelys) scaldii</i> .....	372
<i>samarensis</i> .....	436	<i>(Sphargis) pseudostracion</i> ....	372
<i>Phassus</i> .....	529	<i>rupeliensis</i> .....	372
<i>argentiferus</i> .....	565	<i>Pseudotharrhaleus malindangensis</i> .....	441
<i>triangularis</i> .....	539, 565	<i>Pseuphophorus rupeliensis</i> .....	372
Philippine Birds, with Descriptions of New and Rare Species.—Additions to the List of, by E. A. Mearns.....	435	<i>Pteronarcys californica</i> .....	532, 560
Philippine Islands, Borneo, Guam, and Mid- way Island, with Descriptions of Three New Forms.—A List of Birds collected by Dr. Paul Bartsch in the, by E. A. Mearns.....	463	<i>Pteropus vampyrus malaccensis</i> .....	490
Philippine Islands.—On a Collection of Re- cent Crinoids from the, by Austin H. Clark.....	391	<i>Ptilodus</i> .....	611, 612, 613
Philippines and Australia.—Fresh-water Sponges in the Collection of the United States National Museum: Part I. Speci- mens from the, by Nelson Annandale.....	627	<i>gracilis</i> .....	616, 623, 626
<i>Philoscia richardsonæ</i> .....	378	<i>mediaevus</i> .....	612, 613, 614, 615, 616
<i>Pictetierinus</i> .....	189	<i>montanus</i> .....	615, 616, 622
<i>Pisobia aurita</i> .....	478	<i>plicatus</i> .....	614, 617, 618
<i>Plagiaulacidae</i> .....	613	<i>serratus</i> .....	622
<i>Plagiaulax</i> .....	612, 624, 625, 626	<i>trouessartianus</i> .....	614, 623
<i>Plathemis lydia</i> .....	658, 660, 661, 662, 663, 664, 668	<i>Ptilodus</i> , with Descriptions of New Species.— Notes on the Fossil Mammalian Genus, by J. W. Gidley.....	611
<i>Platyphylax designata</i> .....	565	<i>Ptilometra</i> .....	365, 400
<i>subfasciata</i> .....	565	<i>pulcherrima</i> .....	400
<i>Podogygnura</i> .....	449, 450	<i>Pulvinus cuneatus</i> .....	477
<i>Poliolophus urostictus</i> .....	470	<i>leucomelas</i> .....	464
<i>Polocanthus</i> .....	300	<i>Pycnonotus analis</i> .....	470
<i>Polychitonaeris</i> .....	162	<i>goiavier</i> .....	470
<i>atava</i> .....	163	<i>goiavier</i> .....	470, 471
<i>Polypsilota striata</i> .....	521	<i>suluensis</i> .....	463, 470, 471
<i>Polysarcus</i> .....	162	<i>plumosus</i> .....	475
<i>atavus</i> .....	162, 163	<i>simplex</i> .....	475
<i>Pomacentridæ</i> .....	600	<i>Pyrgomorphinæ</i> .....	109
<i>Pontiometra</i> .....	397	<i>Pyrgomorphinæ</i> and <i>Locustinæ</i> ( <i>Acridinæ</i> of Authors).—On Brazilian Grasshoppers of the Subfamilies, by James A. G. Rehn.....	109
<i>insperatus</i> .....	397	<i>Pyrotrogon ardens</i> .....	468
<i>Pontoætus leucogaster</i> .....	465	<i>Pyrtherodias manillensis</i> .....	465
<i>Porzanula palmeri</i> .....	477	<i>Pyrrhula leucogenys</i> .....	445, 446
<i>Poteriocrinus</i> .....	190	<i>steerei</i> .....	445, 446
<i>Pratincola caprata</i> .....	471	<i>Raja</i> .....	459
<i>Presbytis cana</i> .....	491	<i>Ramphalcyon capensis gigantea</i> .....	466
<i>cristata</i> .....	489, 491	<i>gouldi</i> .....	466
<i>rhionis</i> .....	491	<i>smithi</i> .....	463, 466
<i>Prioniturus malindangensis</i> .....	437	Rare Species.—Additions to the List of Phil- ippine Birds, with Descriptions of New and, by E. A. Mearns.....	435
<i>waterstradti</i> .....	438	<i>Ratufa bulana</i> .....	482, 483, 489
<i>Prionolopha</i> .....	117	<i>carimonensis</i> .....	489
<i>serrata</i> .....	117	<i>condurensis</i> .....	490
<i>Prisma</i> .....	375	<i>confinis</i> .....	490
<i>Procolpia</i> .....	110	<i>conspicua</i> .....	490
<i>minor</i> .....	110	<i>insignis</i> .....	482, 483, 490
<i>Promachocrinus</i> .....	363	<i>notabilis</i> .....	490
<i>Prosopis philippinensis</i> .....	414	Rays, of the Family <i>Narcobatidæ</i> , from Deep Water off the Southern Atlantic Coast of the United States.—Descriptions of Two New Species of Electric, by B. A. Bean and A. C. Weed.....	677
<i>Prosopium</i> .....	430	Recent Crinoids.—Descriptions of Seventeen New Species of, by A. H. Clark.....	633
<i>Protheria</i> .....	624	Recent Crinoids from the Philippine Islands.—On a Collection of, by Austin H. Clark.....	391
<i>Protomachus depressus</i> .....	110	Rehn, James A. G. On Brazilian Grasshop- pers of the Subfamilies <i>Pyrgomorphinæ</i> and <i>Locustinæ</i> ( <i>Acridinæ</i> of Authors).....	109
<i>Protoparce cingulata</i> .....	565	Remarkable New Genus of Unstalked Cri- noids.— <i>Comatilia</i> , A, by A. H. Clark.....	361
<i>Psænythia annulata</i> .....	417		
<i>philanthoides</i> .....	417		
<i>Psathyrometra</i> .....	648		
<i>mira</i> .....	648		
<i>Psephophorus</i> .....	373		
<i>calvertensis</i> .....	370, 371, 372		
<i>ecœnus</i> .....	373		



	Page.		Page.
Remarks on the Insectivores of the Genus <i>Gymnura</i> ; by Marcus Ward Lyon.....	449	(Say).—The Isopod Crustacean <i>Ancinus depressus</i> , by Harriet Richardson.....	173
Reptile <i>Camptosaurus</i> , with a Revision of the Species of the Genus, and Descriptions of Two New Species.—Ostrology of the Jurassic, by Charles W. Gilmore.....	197	<i>Scarichthyidae</i> .....	602
Revised List.—Additional Notes on Mammals of the Rhio-Linga Archipelago, with Descriptions of New Species and a, by M. W. Lyon, jr.....	479	<i>Schistocera</i> .....	157
Revision of the Crinoid Family <i>Comasteridae</i> , with Descriptions of New Genera and Species, by A. H. Clark.....	493	<i>americana</i> .....	158
Revision of the Species of the Genus, and Descriptions of Two New Species.—Osteology of the Jurassic Reptile <i>Camptosaurus</i> , with a, by Charles W. Gilmore.....	197	<i>desiliens</i> .....	157, 158
<i>Rhinomyias</i> <i>ocularis</i> .....	463, 469	<i>flavofasciata</i> .....	157
<i>ruficauda mindanensis</i> .....	439	<i>pallens</i> .....	158
<i>ruficauda</i> .....	439	<i>Sciuropterus amoenus</i> .....	490
<i>Rhinosciurus laticaudatus</i> .....	490	<i>Sciurus abbottii</i> .....	510
Rhio-Linga Archipelago, with Descriptions of New Species and a Revised List.—Additional Notes on Mammals of the, by M. W. Lyon, jr.....	479	<i>carimonensis</i> .....	490
<i>Rhipidura cyaniceps</i> .....	469	<i>condurensis</i> .....	490
<i>nigritorquis</i> .....	469	<i>director</i> .....	509, 510
<i>uranie</i> .....	477	<i>peninsularis</i> .....	482, 490
<i>Rhizocrinus</i> .....	188, 362, 365	<i>tedongus</i> .....	510
<i>brevis</i> .....	675, 676	<i>tenuis</i> .....	490
<i>conifer</i> .....	674	<i>vittatus</i> .....	510
<i>Rhizocrinus</i> .—Four New Species of the Crinoid Genus, by A. H. Clark.....	673	<i>vittatus</i> .....	482
<i>Rhizocrinus lofotensis</i> .....	673, 674, 675, 676	<i>Scolopocryptops</i> .....	537, 541, 561
<i>rawsoni</i> .....	673, 676	<i>Scutigera</i> .....	518
<i>robustus</i> .....	675	Seventeen New Species of Recent Crinoids.—	
<i>sabæ</i> .....	675	Descriptions of, by Nelson Annandale.....	633
<i>verilli</i> .....	674, 676	<i>Shinto rosary</i> .....	344
<i>weberi</i> .....	674, 676	Shrimps of the Genus <i>Synalpheus</i> .—The	
<i>Rhyacophilus glareola</i> .....	464	American Species of Snapping, by Henri	
Richardson, Harriet. Description of a New		Coutière.....	1
Isopod of the Genus		<i>Siasi pigmy woodpecker</i> .....	438
<i>Jacropsis</i> from Pata-		<i>Silpha surinamensis</i> .....	562
gonia.....	421	<i>Simia cristata</i> .....	489
The Isopod Crusta-		<i>fascicularis</i> .....	488
cean <i>Acanthoniscus</i>		<i>Siphostoma yoshi</i> .....	597
Spiniger Kinahan		<i>Sirex flavipennis</i> .....	567
redescribed.....	431	<i>Skate (Dactylobatus armatus)</i> from Deep	
The Isopod Crusta-		Water off the Southern Atlantic Coast of	
cean, <i>Ancinus de-</i>		the United States.—Description of a New,	
pressus (Say).....	173	by B. A. Bean and A. C. Weed.....	459
<i>Riu Kiu Islands</i> .—Descriptions of New Gen-		<i>Skull and the Brain of Triceratops</i> , with Notes	
era and Species of Fishes from Japan and		on the Brain-cases of <i>Iguanodon</i> and <i>Mega-</i>	
the, by J. O. Snyder.....	597	losaurus.—On the, by O. P. Hay.....	95
Robbins, W. W., and T. D. A. Cockerell.		<i>Slugs of the Genus Veronicella</i> .—Notes on	
Notes on Two Slugs of the Genus <i>Veroni-</i>		Two, by W. W. Robbins and T. D. A.	
cella.....	381	Cockerell.....	381
Roman Catholic rosary.....	370	<i>Smarana</i> .....	334
Rosaries in the United States National Mu-		<i>Snake from Panama</i> .—Description of a New,	
seum.—The Collection of, by Immanuel M.		by Leonhard Stejneger.....	457
Casanowicz.....	333	Snapping Shrimps of the Genus <i>Synal-</i>	
<i>Salmo clupearformis</i> .....	171	pheus.—The American Species of, by Henri	
Samar brown pigeon.....	436	Coutière.....	1
<i>Sarcops calvus</i> .....	475	<i>Snodgrass, Robert Evans</i> , The Thorax of In-	
<i>melanonotus</i> .....	475	sects and the Articulation of the Wings... ..	511
		<i>Snyder, John Otterbein</i> . Descriptions of New	
		Genera and Spec-	
		ies of Fishes from	
		Japan and the Riu	
		Kiu Islands.....	597
		and David Starr Jordan.	
		Description	
		of a New White-	
		fish ( <i>Coregonus</i>	
		<i>oregonius</i> ) from	
		McKenzie River.	
		Oregon.....	425
		<i>Soleidae</i> .....	609
		<i>South China Sea</i> .—A New Squirrel from	
		Direction Island, by M. W. Lyon, jr.....	509

Page.		Page.
Southern Atlantic Coast of the United States.—Description of a New Skate ( <i>Dactylobatus armatus</i> ) from Deep Water off the, by B. A. Bean and A. C. Weed .....	459	<i>Spharominae colobranchiatae</i> ..... 174
Southern Atlantic Coast of the United States.—Descriptions of Two New Species of Electric Rays, of the Family Narcobatidae, from Deep Water off the, by B. A. Bean and A. C. Weed .....	677	<i>platybranchiatae</i> ..... 174
<i>Spathium</i> .....	109	<i>Sphargis pseudostracion</i> ..... 372
<i>cyanopterum</i> .....	110	<i>rupeliensis</i> ..... 372
Species.—Additions to the List of Philippine Birds, with Descriptions of New and Rare, by E. A. Mearns.....	435	<i>Sphecius speciosus</i> ..... 567
Species and a Revised List.—Additional Notes on Mammals of the Rio-Linga Archipelago, with Descriptions of New, by M. W. Lyon, jr.....	479	<i>Spilornis holospilus</i> ..... 465
Species.—Notes on the Fossil Mammalian Genus <i>Ptilodus</i> , with Descriptions of New, by J. W. Gidley.....	611	<i>Spiniger Kinahan</i> redescribed.—The Isopod Crustacean <i>Acanthoniscus</i> , by Harriet Richardson..... 431
Species of Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of Three New, by David Starr Jordan and B. W. Evermann.....	165	<i>Spinoliella obscurella</i> ..... 417
Species of Electric Rays, of the Family Narcobatidae, from Deep Water off the Southern Atlantic Coast of the United States.—Descriptions of Two New, by B. A. Bean and A. C. Weed.....	677	<i>zebrata</i> ..... 417
Species of Fishes from Japan and the Riu Kiu Islands.—Descriptions of New Genera and, by J. O. Snyder.....	597	<i>Spodromantis guttata</i> ..... 539, 555
Species of Fossil Turtles, <i>Toxochelys stenopora</i> and <i>Chisternon? interpositum</i> , the Latter hitherto Unknown.—Description of Two, by Oliver P. Hay.....	191	Sponges in the Collection of the U. S. National Museum, Part I. Specimens from the Philippines and Australia.—Fresh-water, by Nelson Annandale..... 627
Species of Isopods from the Coast of California.—Four New, by S. J. Holmes and M. E. Gay.....	375	<i>Spongilla</i> ..... 627
Species of Leatherback Turtle from the Miocene of Maryland.—Description of a New, by William Palmer.....	369	<i>clementis</i> ..... 631
Species of Recent Crinoids.—Descriptions of Seventeen New, by A. H. Clark.....	633	<i>lacustris</i> ..... 629
Species of Snapping Shrimps of the Genus <i>Synalpheus</i> .—The American, by Henri Coutière.....	1	<i>philippinensis</i> ..... 629, 631, 632
Species of the Crinoid Genus <i>Rhizocrinus</i> .—Four New, by A. H. Clark.....	673	<i>proliferans</i> ..... 629
Species of Whitefish.—Descriptions of Three New Species of Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the Great Lakes of America; with a Note on the, by David Starr Jordan and B. W. Evermann.....	165	<i>sceptrioides</i> ..... 627, 629
Species.—Osteology of the Jurassic Reptile <i>Camptosaurus</i> , with a Revision of the Species of the Genus, and Descriptions of Two New, by Charles W. Gilmore.....	197	<i>Spongiphora</i> ..... 532
Species.—Revision of the Crinoid Family Comasteridae, with Descriptions of New Genera and, by A. H. Clark.....	493	<i>apicidentata</i> ..... 539, 561
Specimens from the Philippines and Australia.—Fresh-water Sponges in the Collection of the U. S. National Museum. Part I, by Nelson Annandale.....	627	<i>brunneipennis</i> ..... 561
		<i>Springer, Frank.</i> A New American Jurassic Crinoid..... 179
		Squirrel from Direction Island, South China Sea.—A New, by M. W. Lyon, jr..... 509
		Steere bullfinch..... 445
		<i>Stegosaurus marshii</i> ..... 292
		<i>sulcatus</i> ..... 198
		Stejneger, Leonhard. Description of a New Snake from Panama..... 457
		<i>Stenacris</i> ..... 135
		<i>chlorizans</i> ..... 135
		<i>coccineipes</i> ..... 135, 136
		<i>cylindrodes</i> ..... 135, 136
		<i>gracilis</i> ..... 135, 136
		<i>mexicana</i> ..... 135
		<i>vitreipennis</i> ..... 135
		<i>Stenometra</i> ..... 402
		<i>arachnoides</i> ..... 402
		<i>Stenopola</i> ..... 141
		<i>bohlsii</i> ..... 141
		<i>puncticeps</i> ..... 141
		<i>Stenopora</i> and <i>Chisternon? interpositum</i> , the Latter hitherto Unknown.—Description of Two Species of Fossil Turtles, <i>Toxochelys</i> , by Oliver P. Hay..... 191
		<i>Stephanometra</i> ..... 399, 639
		<i>coronata</i> ..... 639
		<i>tenuipinna</i> ..... 399, 639
		<i>Sterna bergii boreotis</i> ..... 464
		<i>fuscata crissalis</i> ..... 477
		<i>longipennis</i> ..... 435
		<i>Stratospongilla</i> ..... 631, 632
		<i>Streptopelia dussumieri</i> ..... 464
		Subfamilies <i>Pyrgomorphinae</i> and <i>Locustinae</i> ( <i>Aceridinae</i> of Authors).—On Brazilian Grasshoppers of the, by James A. G. Rehn..... 109
		<i>Sulu guava bulb</i> ..... 470
		<i>Sus oi</i> ..... 489
		<i>rhionis</i> ..... 480, 489
		<i>vittatus</i> ..... 480, 489
		<i>Sympetrum rubicundulum</i> ..... 657, 663, 666
		<i>vicinum</i> ..... 665

	Page.		Page.
<i>Synalpheus</i> .....	1	<i>Synalpheus</i> <i>noti filii</i> .....	6, 9, 40, 41
<i>acanthitelsonis</i> .....	10, 12, 13, 18, 31, 34	<i>otiosus</i> .....	9, 91
<i>albatrossi</i> .....	9	<i>pandionis</i> .....	8, 10, 64, 67, 68, 69
<i>amboinæ</i> .....	9	<i>extentus</i> .....	8, 10, 69
<i>androsi</i> .....	9, 10, 82	<i>paraneomeris</i> .....	9, 13, 27, 35, 39, 90, 91
<i>apioceros</i> .....	6, 10, 18, 19, 27, 29, 13, 30, 31	<i>oxyceros</i> .....	9
<i>desterroensis</i> .....	6, 10, 31	<i>prolatus</i> .....	9
<i>leiopes</i> .....	6, 10, 30	<i>paraneptunus</i> .....	9, 10, 16, 86
<i>mayaguensis</i> .....	6, 10, 30	<i>parfaiti</i> .....	10, 67, 68, 69
<i>sanjosci</i> .....	6, 10, 19, 29	<i>paulsoni</i> .....	10, 12, 15, 18, 19, 23, 24, 92
<i>bakeri</i> .....	9, 14, 91	<i>kurracheensis</i> .....	10, 12, 23, 25, 92
<i>bianguiculatus</i> .....	10, 16, 87, 93	<i>liminaris</i> .....	10, 23, 92
<i>exilipes</i> .....	10, 93	<i>rameswarensis</i> .....	10, 23
<i>pachymeris</i> .....	10	<i>senegambiensis</i> .....	10, 92
<i>brevicarpus</i> .....	1, 2, 7, 10, 15, 46, 50, 52	<i>paulsonoides</i> .....	7, 13, 18, 19, 24, 25
<i>guerini</i> .....	2, 7, 10, 53	<i>pectiniger</i> .....	3, 8, 10, 17, 18, 55, 69, 78, 83
<i>brooksii</i> .....	3, 9, 10, 18, 20, 69, 73, 76, 77, 85	<i>pescadorensis</i> .....	10, 85, 87
<i>cleuthere</i> .....	9, 10, 73	<i>physocoles</i> .....	9, 91
<i>strepsiceros</i> .....	10, 73	<i>pococki</i> .....	9
<i>carinatus</i> .....	9	<i>rathbunæ</i> .....	8, 10, 18, 20, 84, 87
<i>charon</i> .....	9, 90	<i>sanctithomæ</i> .....	9, 10, 61
<i>comatularum</i> .....	4, 9	<i>sanlucasi</i> .....	6, 9, 41, 42, 43
<i>demani</i> .....	9	<i>sladeni</i> .....	10, 16, 93
<i>digueti</i> .....	7, 10, 15, 48, 50	<i>spinifrons</i> .....	10, 16
<i>ecuadorensis</i> .....	7, 10, 65	<i>spiniger</i> .....	10, 16, 17
<i>fossor</i> .....	9, 91	<i>stimpsoni</i> .....	9
<i>fritzmülleri</i> .....	6, 9, 14, 35, 38, 39, 40, 42, 43	<i>maldivensis</i> .....	9
<i>elongatus</i> .....	6, 9, 38	<i>tanneri</i> .....	8, 10, 20, 69, 78
<i>goodei</i> .....	9	<i>Synalpheus</i> .—The American Species of Snap-	
<i>occidentalis</i> .....	9, 10, 60, 61	<i>ping Shrimps of the Genus, by Henri Cou-</i>	
<i>grampusi</i> .....	8, 10, 62, 65, 67, 68, 69	<i>tière</i> .....	1
<i>gravieri</i> .....	9, 90	<i>Synalpheus townsendi</i> .....	6, 10, 13, 17, 27, 32, 33, 35, 39
<i>haddoni</i> .....	10	<i>brevispinis</i> .....	6
<i>hastilicrassus</i> .....	10, 12, 13, 31, 33, 34	<i>mexicanus</i> .....	6, 10, 35
<i>hemphilli</i> .....	6, 9, 14, 18, 38, 39, 42	<i>productus</i> .....	6, 10, 35
<i>longicornis</i> .....	6, 9, 20, 39	<i>tricuspidatus</i> .....	10, 12
<i>heroni</i> .....	9, 14	<i>trionychis</i> .....	9, 91
<i>herricki</i> .....	3, 8, 10, 19, 69, 73, 74, 77, 78	<i>triunguiculatus</i> .....	9, 91
<i>angustipes</i> .....	8, 10, 20, 78	<i>tumidomanus</i> .....	10, 12, 24, 92
<i>dimidiatus</i> .....	8, 10, 20, 77, 78	<i>Syngnathidæ</i> .....	597
<i>hululensis</i> .....	10, 12, 24, 92	<i>Tabanus atratus</i> .....	568
<i>levimanus</i> .....	10, 66, 90	<i>Tæniopoda</i> .....	128
<i>var. parfaiti</i> .....	64	<i>Tænipodæ</i> .....	128
<i>latastei</i> .....	7, 10, 13, 18, 24, 25, 26, 27	<i>Tæniopteryx fasciata</i> .....	560
<i>tenuispina</i> .....	7, 10, 26	<i>Tanygnathus lucionensis</i> .....	466
<i>laticeps</i> .....	10, 15	<i>megalorhynchus</i> .....	435
<i>lockingtoni</i> .....	1, 7	<i>Telespyza cantans</i> .....	478
<i>10, 12, 13, 18, 21, 23, 24, 25, 26, 27, 29</i>		<i>Tetragoneuria cynosura</i> .....	656, 658, 665, 666, 667, 668
<i>longicarpus</i> .....	1, 3, 8, 10	<i>spinigera</i> .....	655, 658, 659, 661
<i>17, 18, 20, 53, 55, 56, 57,</i>		<i>Tetrapedia</i> .....	413
<i>59, 60, 69, 79, 80, 85-93</i>		<i>gaullei</i> .....	411
<i>approxima</i> .....	8, 10, 57	<i>picta</i> .....	413
<i>lophodactylus</i> .....	10, 16, 93	<i>Tetropium velutinum</i> .....	524, 562
<i>maccullochi</i> .....	10, 12, 25, 92	<i>Thalassometridæ</i> .....	402, 642
<i>microspiniger</i> .....	9, 90	<i>Thalassometrinæ</i> .....	402, 642
<i>minus</i> .....	1, 2, 7, 10, 15,	<i>Thaumatocrinus</i> .....	362
<i>19, 20, 43, 46, 48, 49, 50, 51, 52, 57</i>		<i>renovatus</i> .....	362
<i>antillensis</i> .....	7, 10, 48	<i>The Isopod Crustacean, Ancinus depressus</i>	
<i>haliensis</i> .....	7, 10, 48	<i>(Say), by Harriet Richardson</i> .....	173
<i>mushaensis</i> .....	10, 18, 24, 92	<i>Theromorpha</i> .....	210
<i>neomeris</i> .....	9, 90, 91	<i>Thorax of Insects and the Articulation of the</i>	
<i>streptodactylus</i> .....	9	<i>Wings.—The, by R. E. Snodgrass</i> .....	511
<i>neptunus</i> .....	10, 15, 87	<i>Three New Forms.—A List of Birds collected</i>	
<i>nilandensis</i> .....	9, 14, 18, 33, 39	<i>by Dr. Paul Bartsch in the Philippine Is-</i>	
<i>oxyceros</i> .....	9, 38, 39	<i>lands, Borneo, Guam, and Midway Island,</i>	
		<i>with Descriptions of, by E. A. Mearns</i> .....	463

	Page.		Page.
Three New Species of Cisco, or Lake Herring ( <i>Argyrosomus</i> ), from the Great Lakes of America; with a Note on the Species of Whitefish.—Descriptions of, by David Starr Jordan and B. W. Evermann.....	165	Two New Species.—Osteology of the Jurassic Reptile <i>Camptosaurus</i> , with a Revision of the Species of the Genus, and Descriptions of, by Charles W. Gilmore.....	197
Tibetan rosaries.....	336	Two Slugs of the Genus <i>Veronicella</i> .—Notes on, by W. W. Robbins and T. D. A. Cockerell.....	381
Torosaurus latus.....	95	Two Species of Fossil Turtles, <i>Toxochelys stenopora</i> and <i>Chisternon? interpositum</i> , the Latter hitherto Unknown.—Description of, by Oliver P. Hay.....	191
Toxochelys bauri.....	192	<i>Tylos punctatus</i> .....	376
<i>latiremis</i> .....	192	Type of Basketwork.—Anyam Gila (Mad Weave): A Malaysian, by Otis T. Mason..	385
<i>stenopora</i> .....	191	Umbellularia.....	184
Toxochelys stenopora and Chisternon? interpositum, the Latter hitherto Unknown.—Description of Two Species of Fossil Turtles, by Oliver P. Hay.....	191	United States.—Description of a New Skate ( <i>Dactylobatus armatus</i> ) from Deep Water off the Southern Atlantic Coast of the, by B. A. Bean and A. C. Weed.....	459
Trachodon.....	246	United States.—Descriptions of two New Species of Electric Rays, of the Family <i>Narcobatidae</i> , from Deep Water, off the Southern Atlantic Coast of the, by B. A. Bean and A. C. Weed.....	677
Tragulus flavicollis.....	481, 489	United States National Museum.—The Collection of Rosaries in the, by Immanuel M. Casanowicz.....	333
<i>formosus</i> .....	489	United States National Museum. Part I. Specimens from the Philippines and Australia.—Fresh-water Sponges in the Collection of the, by Nelson Annandale.....	627
<i>lutescens</i> .....	489	Unknown.—Description of Two Species of Fossil Turtles, <i>Toxochelys stenopora</i> and <i>Chisternon? interpositum</i> , the Latter hitherto, by Oliver P. Hay.....	191
<i>nigrocinctus</i> .....	489	Unstalked Crinoids.— <i>Comatilia</i> , a Remarkable New Genus of, by A. H. Clark.....	361
<i>nigricollis</i> .....	489	<i>Uroloncha fuscans</i> .....	475
<i>perflavus</i> .....	481, 489	U. S. National Museum.—Descriptions of some Bees in the, by T. D. A. Cockerell.....	411
<i>pretiellus</i> .....	489	<i>Veronicella</i> .....	381
<i>pretiosus</i> .....	489	<i>agassizi</i> .....	382, 383
<i>rubeus</i> .....	489	<i>brunnea</i> .....	383
<i>subrufus</i> .....	489	<i>gilsoni</i> .....	382, 383
Triceratops.....	97	<i>moreleti</i> .....	384
<i>flabellatus</i> .....	98	<i>Veronicella</i> .—Notes on Two Slugs of the Genus, by W. W. Robbins and T. D. A. Cockerell..	381
<i>horridus</i> .....	102	<i>Veronicella schivelyæ</i> .....	383
<i>prosus</i> .....	220	<i>bahamensis</i> .....	383, 384
<i>serratus</i> .....	95, 102, 104, 105	<i>willeyi</i> .....	381, 383
<i>sulcatus</i> .....	96, 104	<i>Vespertilio muricola</i> .....	488
Triceratops, with Notes on the Braincases of <i>Iguanodon</i> and <i>Megalosaurus</i> .—On the Skull and the Brain of, by O. P. Hay.....	95	<i>Vilernæ</i> .....	152
Trichosurus.....	625	<i>Viverra gymnura</i> .....	451
Triscædecanimios.....	183	<i>tangalunga</i> .....	499
Tropidacris.....	134	Water off the Southern Atlantic Coast of the United States.—Description of a New Skate ( <i>Dactylobatus armatus</i> ) from deep, by B. A. Bean and A. C. Weed.....	459
<i>cristata</i> .....	134	Water off the Southern Atlantic Coast of the United States.—Descriptions of Two New Species of Electric Rays, of the Family <i>Narcobatidae</i> , from deep, by B. A. Bean and A. C. Weed.....	677
<i>dux</i> .....	134	Weave): A Malaysian Type of Basketwork.—Anyam Gila (Mad, by Otis T. Mason.....	385
<i>grandis</i> .....	134		
Tropinotus.....	118		
<i>angulatus</i> .....	118		
<i>attenuatus</i> .....	118		
<i>gracilis</i> .....	118		
<i>obsoletus</i> .....	121		
Tropiometridæ.....	400		
Trulla itina.....	609		
Tuminadæ scops owl.....	437		
Tupaia castanea.....	490		
<i>ferruginea batamana</i> .....	490		
<i>malaccana</i> .....	490		
<i>phocura</i> .....	490		
<i>tana</i> .....	490		
Turritellæ.....	423		
Turtle from the Miocene of Maryland.—Description of a New Species of Leatherback, by William Palmer.....	369		
Turtles, <i>Toxochelys stenopora</i> and <i>Chisternon? interpositum</i> , the Latter hitherto Unknown.—Description of Two Species of Fossil, by Oliver P. Hay.....	191		
Two New Species of Electric Rays, of the Family <i>Narcobatidae</i> , from Deep Water off the Southern Atlantic Coast of the United States.—Descriptions of, by B. A. Bean and A. C. Weed.....	677		



Page.		Page.
Weed, Alfred C., and Barton A. Bean. De- scription of a New Skate ( <i>Dactylobatus</i> <i>armatus</i> ) from deep Water off the Southern Atlantic Coast of the United States.....		468
Weed, Alfred C., and Barton A. Bean. De- scriptions of two New Species of Electric Rays, of the Family <i>Narcobatidae</i> , from Deep Water off the Southern Atlantic Coast of the United States.....		114
Whitefish ( <i>Coregonus oregonius</i> ) from Mc- Kenzie River, Oregon.—Description of a New, by David S. Jordan and J. Otterbein Snyder.....		124
Whitefish.—Descriptions of Three New Spe- cies of Cisco, or Lake Herring ( <i>Argyrosom-</i> <i>us</i> ), from the Great Lakes of America; with a Note on the Species of, by David Starr Jordan and B. W. Evermann.....	459	157
Wilson, Charles Branch. Dragonflies of the Mississippi Valley collected during the Pearl Mussel Investigations on the Missis- sippi River, July and August, 1907.....		157
Wings.—The Thorax of Insects and the Artic- ulation of the, by R. E. Snodgrass.....		415
		416
		415
		545
	677	438, 463, 468
		433
		468
	425	371
		132
		132
		132
		134
	165	605
		473
		443
		443
	653	473
		473
	511	633

















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